II. PEDOCHEMICAL CHARACTERISTICS OF SOME SOILS OF CHITTORGARH AND JODHPUR DISTRICTS OF RAJASTHAN

By

S. SINGH *and* G. S. BHANDARI

College of Agriculture, Banaras Hindu University, Varanasi-5

ABSTRACT

A study of four different soil types of Rajasthan has been done with respect to their pedochemical properties, and their possible significance in the formation of these soils is discussed. All the soil types irrespective of their mechanical composition, show increased accumulation of calcium carbonate with depth. The soils are invariably rich in plant mineral nutrients. Clays of the different depths of all the soils have been investigated in respect of their elementary composition and exchange capacities. The results show the clays of soil type 1 to be of montmorillonitic nature while those of the other types approach closer to it.

It may reasonably be stated that dark grey heavy clay soil 1 shows all the physical and chemical properties similar to those of 'black cotton soils'. Therefore, the soil may be classed with the latter group. Soil type 2 is reddish brown and constitutes the characteristic 'reddish brown soils' of the southern Rajasthan. These soils are, however, quite different from 'red soils' of the southern India which are characterised by the absence of line *Kankar* and free carbonates. Soil type 3 is a typical alkaline soil whereas type 4 is desert soil of aeolian origin.

The present paper is ninth in the series of a study dealing with some typical soils of Rajasthan, Singh and Bhandari,[1-8]. It reports pedochemical characteristics of four typical soil profiles obtained from Chittorgarh and Jodhpur districts of the State.

Climate and Geology.

Normal rainfall and temperature figures of the localities are given in Table 1.

TABLE 1

Normal Rainfall and Temperature*

Locality	Normal rainfall (inch.)	Temperature (°F)			
		1958		1959	
		Max.	Min.	Max.	Min.
Kapasan	31·25	109·2	38·7	107·7	37·2
Udaipur	29·45	118·5	37·4	114·8	41·0

The Chittorgarh district constitutes the western plateau region of the State. The area is characterised by good showers, received mostly in the months of June, July and August. The Jodhpur district constitutes the eastern part of the N.-W. Rajasthan desert. This region is exclusively arid, and is characterised by deficient rainfall, clear skies, extremes of temperature, high evaporation and sparse vegetation throughout.

The main constituent rocks of the area are quartzites. conglomerates, talc-schists, hornblende, chlorites, granite gneisses, sandstones and limestones. Jodhpur area is mostly covered by sand dunes but in the plains isolated hills of solid rocks are scattered.

SOIL ANALYSIS

The soil samples were passed through a 2 mm. sieve and used throughout. The analysis methods followed were the same as described in the previous paper.

The separation of the clays of profiles 1 to 2 (here after called types 1 to 3) was brought about by boiling 50 gm. of soil sample with 200 ml. of water for 10 minutes, agitated under electric stirrer for 25 minutes and the clay suspension was siphoned off after standing for 30 hrs. The process was repeated after making appropriate additions of water every time till about 3 litre clay suspension was collected. The clays from the desert soil were separated by boiling the soil (50 gm./200 ml. water) for 10 minutes, added 200 ml. of (N) NaCl soln. to it, stirred, kept overnight, removed excess of the salt solution by washing on Buchner funnel, added 5 ml. of (N) NaOH soln. and stirred for 15 minutes. The clay suspension so obtained was siphoned off after 30 hrs. as above. Then the suspension was evaporated on boiling water bath to dryness, ground to pass through 0·1 mm. sieve and used for analysis. The clays were analysed for mineral constituents after fusion with Na_2CO_3.

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*Source—A basic statistics of Rajasthan, Govt. of Raj. Pub.; Jaipur, 1960,

TABLE 2

Morphological description

Profile No.	Depth in inch	Description	Remarks
1	0-13	Very dark grey (D 10YR3/1) clay loam, blocky with mixed granular structure, compact and very hard, sticky and plastic when moist, greasy, profuse rootlets, vertical cracking when dry, effervescence, aquatic animal shells and neutral.	Under-lain by soft cal careous substratum
	13-25	Dark grey (D 10YR4/1) clay loam, weak sub-angular blocky, compact and very hard when dry, sticky and plastic when moist, rootlets, effervescence, greasy, aquatic animal shells and neutral.	
	25-38	Dark grey (D 10YR4/1) clay loam, strongly angular blocky, compact and very hard, stricky and plastic when moist, effervescence and slightly alkaline.	
	38-60	Grey (D 10YR6/1) clay loam, blocky, compact and very hard, sticky and plastic when moist, slight effervescence, slight calcareous concretions and slightly alkaline.	
2	0-14	Very dark reddish brown (D 5YR5/4) loam, coarse angular blocky, profuse roots, non-plastic and friable when moist, gritty and neutral.	Under-lain by soft calcareous substratum mixed with sandstones cemented with carbonates
	14-29	Dark reddish brown (D 5YR3/2) loam, coarse blocky, non-plastic and friable when moist, slight efiervescence and neutral.	
	29-43	Dark reddish brown (D 5YR3/3) loam, under-developed, profuse calcareous concretions up to 2″ diameter and slightly alkaline.	
	43-62	Reddish brown (D 5YR5/4) loam, structureless, abundant calcareous concretions up to 4″ diameter and slightly alkaline.	

Table 2—(Concld.)

Profile No.	Depth in inch	Description	Remarks
3	0-6	Pale yellow (D 5Y8/4) sandy loam, blocky with mixed columnar, profuse effervescence, compact and hard, gritty and alkaline.	Under-lain by highly calcareous hard pan and sandstones cemented with carbonates
	6-20	Pale yellow (D 5Y8/4) loam, columnar, compact and hard, profuse effervescence, hard bed of sandstones up to 3-4″ thickness, gritty and alkaline.	
	20-39	Pale olive (D 5Y6/3) loam, columnar, compact and hard, profuse effervescence, sandstones cemented with lime concretions in abundance and alkaline.	
	39-60	Pale olive (D 5Y6/4) loam, columnar, compact and hard, gritty abundance of lime concretions and alkaline.	
4	0-8	Yellowish brown (D 10YR5/4) sandy, quartz pebbles and sandstones of varying size, thick and thin roots, effervescence and neutral.	Under-lain by calcareous bed mixed with pebbles and sandstones cemented with carbonates.
	8-22	Yellowish brown (D 10YR5/4) sandy loam, mild effervescence, layer of sandstone pieces of 1-4″ thickness, rootlets and neutral.	
	22-43	Yellowish brown (D 10YR5/4) sandy loam, profuse effervescence, rootlets, quartz and sandstone pebbles and neutral.	
	43-55	Yellowish brown (D 10YR5/4) sandy loam, profuse effervescence, quartz pebbles and sandstone pieces and neutral.	
	55-62	Pale brown (D 10YR6/3) sandy loam, profuse effervescence, quartz pebbles and sandstone pieces cemented with carbonate and neutral.	
	62-72	Pale brown (D 10YR6/3) sandy loam, 'Kankar' of various sizes and consistency cemented with sandstones, profuse effervescence and neutral.	

Soil types 1 and 3 were sampled from Kapasan Farms lying 1 and 1½ miles respectively to the north of the railway station and represents the typical 'Kali' and 'Urdi' soils. The 'Kali' constitutes the most fertile cotton and sugarcane growing soil of the level plains. The profile, however, showed no clear cut differentiations into horizons but some colour demarkations could be observed which formed the basis for sampling. The land is well irrigated, water table varies from 15-25 feet and is rarely subjected to erosion. Cropping vegetation consists of maize, barley, gram, sugarcane and cotton.

Usar (locally called the 'urdi') soils includes saline and alkaline soils and are usually found in small land patches. There was absence of visible salt crust on the surface when the samples were taken in January and, therefore the surface sample was taken to plough depth. Other samples were taken by depths as the profile showed indistinct horizons. The land was barren with almost little vegetative growth.

The site for soil type 2 is Balarda village Farm lying 2 miles to the north of the railway station. This locality represents the typical wheat growing 'Bhuri' soils, usally occurring on high level plains as compared to the 'Kali'. The area is well irrigated and water table is 25-30 feet. Maize, jawar, pulses, wheat and barley constitute the cropping vegetation.

Soil type 4 was sampled from the Govt. Agric. Farm, Mondore (Jodhpur). The profile is typical of the desert or arid zone soils. Topography of the land is plain. Locally the soils are called the 'Bhuri'. The land is well irrigated and water table varies from 60·80 feet. Bajra, wheat, barley and pulses are main crops of the locality.

RESULTS AND DISCUSSION

Soil type 1 is characteristically dark grey heavy clay and remarkably differs from dark grey alluvial soils of Kota region. It (Type 1), however, seems to resemble more to 'black cotton soils'. The reddish brown soil shows no well marked horizons and is underlain by soft calcareous sub-stratum mixed with sandstones cemented with carbonates-a characteristic feature of reddish brown soils of the southern Rajasthan. The morphological features of soil type 3 are the characteristics of alkaline soils. Sandy soil 4, representative of desert region of Rajasthan, is under-lain by calcareous bed mixed with pebbles and sandstones cemented with carbonates. This is a characteristic feature of these desert soils.

TABLE 3

Mechanical composition of the soils

(Per cent on oven-dry basis)

Soil type	Depth in inches	Moisture	Loss on ignition	Calcium carbo-nate	Coarse sand	Fine sand	Silt	Clay
1	0-13	7·4	7·22	4·00	2·40	19·50	21·50	55·50
	13-25	6·6	7·23	5·00	3·00	22·50	17·75	54·25
	25-38	5·1	6·80	5·00	3·51	23·50	19·92	51·21
	38-60	4·8	6·10	4·00	3·90	23·75	17·53	51·00
2	0-14	3·2	4·69	4·92	5·00	49·20	16·75	29·00
	14-29	3·3	5·80	4·27	5·10	48·75	12·75	30·25
	29-43	2·6	8·81	7·39	4·72	50·75	14·21	24·36
	43-62	1·6	10·99	15·50	2·00	51·00	15·50	19·91
3	0- 6	1·0	5·53	7·94	5·50	60·65	11·25	16·75
	6-20	1·0	6·02	11·75	4·50	68·82	12·50	20·00
	20-39	1·78	10·44	15·89	4·00	47·80	14·25	26·29
	39-60	2·3	13·59	8·12	3·10	46·50	14·90	28·72
4	0- 8	0·7	2·18	2·57	9·50	65·72	9·53	15·50
	8-22	0·3	2·17	2·13	12·29	73·31	2·25	10·10
	22-43	0·6	2·29	1·92	6·72	68·42	5·00	18·75
	43-55	0·9	4·16	4·16	7·31	68·91	2·50	19·99
	55-62	1·0	7·29	7·29	2·92	70·46	4·10	19·75
	62-72	1·6	8·00	8·00	11·49	65·10	4·59	14·25

Type 1. Loss on ignition and moisture figures decrease with depth evidently as a result of decrease in clay. The surface and bottom layers contain equal amounts of calcium carbonate. The same is true with other two layers. The coarse and fine sand fractions increase with depth while silt shows uneven distribution. Clay is high in the surface layer and decreases with depth and silt and clay together form 77 per cent of the mechanical separates in the surface layer. The results signify greater decomposition in the surface layer.

Type 2. Moisture figures decrease with depth as that of clay. Loss on ignition figures increase with depth possibly due to increase in calcium carbonate. Almost 54 per cent of the soil separate are present as the coarse and fine sand fractions. Silt and clay together show a tendency of decrease with depth suggesting greater degree of weathering in the surface soil with little mechanical eluviation.

Type 3. Moisture figures follow the trend of clay. Loss on ignition figures increase with depth evidently as results of increase in clay and calcium carbonate.

The coarse and fine sand fractions together amount to 66·05 and 49·60 per cents in surface and bottom layers respectively. There is general increase in silt and clay with depth. This aspect has been discussed later.

Type 4. Loss on ignition figures appear to be correlated with those of calcium carbonate. The mechanical separates show uneven distribution throughout the profile. Clay and silt are low and the coarse and the fine sand fractions together amount to nearly 75 per cent because of the sandy nature of the profile. The subsoil is high in clay than the surface one partly owing to aeolian nature of the profile and also partly as a result of its mechanical eluviation.

TABLE 4

Physicochemical analysis

(Per cent on oven-dry basis)

Soil type	Depth in inches	pH	Water holding capacity	T.B.E.C.*	Total organic carbon	Total nitrogen	C/N	Total water soluble salts
1	0-13	7·2	62·25	59·9	0·732	0·101	7·2	0·12
	13-25	7·2	58·00	51·7	0·589	0·100	5·8	0·13
	25-38	7·8	57·5	47·7	0·520	0·075	6·9	0·10
	38-60	7·6	51·10	52·2	0·450	0·043	10·4	0·12
2	0-14	7·3	44·0	26·1	0·580	0·064	9·0	0·09
	14-29	7·4	34·3	23·3	0·667	0·071	9·3	0·08
	29-43	7·4	28·7	23·2	0·485	0·056	8·6	0·11
	43-62	7·8	26·3	19·5	0·252	0·039	6·4	0·12
3	0- 6	9·2	27·4	15·0	0·475	0·040	11·8	0·32
	6-20	8·9	22·4	18·2	0·373	0·025	14·9	0·29
	20-39	8·4	31·5	17·5	0·285	0·029	9·8	0·22
	39-60	8·2	33·9	19·0	0·124	0·028	4·4	0·20
4	0- 8	7·2	22·1	9·7	0·061	0·028	2·1	0·05
	8-22	7·2	18·8	8·2	0·130	0·029	4·4	0·04
	22-44	7·5	23·2	9·9	0·285	0·026	10·9	0·07
	44-55	7·7	19·7	10·2	0·252	0·028	9·0	0·08
	55-62	7·8	18·3	13·3	0·271	0·037	7·3	0·029
	62-72	7·9	19·0	7·9	0·260	0·026	10·0	0·09

*Total base exchange capacity

Type 1. The reaction is slightly alkaline presumably owing to the presence of calcium carbonate. Water holding capacity is high and follows the tend of clay. The exchange capacity is high owing to the high clay content. Carbon and nitrogen are high in the surface layer and decrease with depth. Water soluble salts are low throughout the profile.

Type 2. The pH is on alkaline side and increases with depth due to increase in calcium carbonate. The figures for water holding capacity decrease with depth but not proportionally to clay and is more so with the surface and bottom layers. This appears to be owing to the greater accumulation of silt in both layers which is said to acquire feeble colloidal properties in the presence of calcium carbonate. Except in the second layer, exchange capacity seems to be correlated with the clay content. Carbon and nitrogen are high in the second layer while in others the trend remains the same as in the preceding type. Water soluble salts are low in the surface layers and show slight increase with depth.

Type 3. The pH shows the soil reaction to be highly alkaline. An Examination of data in Table 5 shows that the higher pH of the surface layer is owing to

TABLE 5

Exchangeable cations in soil type 3

(milli-equivalents/ 100 gm.)

Depth in inch	Total exchange capacity	Ca	Mg	Na	K	H
0- 6	15·0	6·1	1·4	5·7	1·9	—
6-20	18·2	11·2	1·5	4·2	1·2	—
20-39	17·5	11·4	1·2	3·9	1·0	—
39-60	19·0	14·5	1·0	2·7	0·6	—

greater amount of exchangeable sodium. The values decrease with depth evidently as a result of increase in exchangeable calcium. The exchange capacity follows the trend of clay. Organic carbon and nitrogen show the same tendency as the preceding types. The increase in clay with depth leading to the formation of somewhat inpervious bed is exemplified by the accumulation of high salt content in the surface layer.

Type 4. The pH is on alkaline side and increases with depth possibly due to higher accumulation of calcium carbonate. Water holding capacity is low because of the sandy nature of the profile and so is the exchange capacity. Water soluble salts are very low owing to the sandy texture.

TABLE 6
HCl-extract analyses
(Per cent on oven-dry basis)

Pofile No.	Depth in inch	HCl solubles	R₂O₃	Al₂O₃	Fe₂O₃	TiO₂	P₂O₅	MgO	CaO	K₂O
1	0-13	33·25	23·64	13·29	9·44	0·81	0·101	2·30	1·96	0·71
	13-25	31·02	22·88	12·59	9·53	0·70	0·066	1·49	2·58	0·81
	25-38	31·69	22·06	11·42	10·14	0·42	0·081	2·30	2·58	0·72
	38-60	31·68	22·84	13·03	9·34	0·40	0·079	2·30	2·16	0·78
2	0-14	20·47	16·08	8·31	7·52	0·21	0·042	1·15	1·27	0·33
	14-29	22·84	19·22	11·08	7·91	0·19	0·044	1·15	1·09	0·39
	29-43	24·51	13·98	7·28	6·33	0·33	0·049	0·95	3·97	0·39
	43-62	26·70	11·26	5·88	4·96	0·37	0·054	0·85	7·53	0·74
3	0-6	20·67	11·20	6·21	4·80	0·12	0·077	1·46	3·94	0·53
	6-20	22·22	10·24	5·25	4·80	0·15	0·041	1·27	5·09	0·52
	20-39	31·10	13·20	7·87	5·03	0·23	0·078	1·57	7·89	0·75
	39-60	39·00	17·56	11·70	5·60	0·19	0·078	1·53	7·33	0·80
4	0-8	13·92	7·94	4·96	2·52	0·42	0·043	1·12	1·15	0·30
	8-22	10·97	4·52	1·55	2·52	0·41	0·048	0·79	1·16	0·90
	22-44	11·36	6·48	3·64	2·40	0·43	0·011	0·87	1·00	0·29
	44-55	11·23	7·28	3·95	2·75	0·57	0·017	0·57	1·12	0·22
	55-62	15·06	6·96	3·97	2·68	0·28	0·031	0·99	2·39	0·37
	62-72	19·47	7·42	4·53	2·56	0·29	0·042	0·93	5·08	0·26

Type 1. HCl-solubles are high as that of clay. The amounts of sesquioxides are very high throughout the profile evidently due to the same reason. The contents of iron oxide and alumina do not vary with depth to a maked degree. Phosphoric acid is high in the surface layer and decreases with depth. Calcium, magnesia and potash behave in an analogous manner, they being distributed somewhat evenly.

Type 2. HCl-solubles increase with depth evidently as a result of increase in calcium. Sesquioxides almost follow the same trend as clay. Iron oxide and the alumina behave in a similar manner, they being high in the seoond layer and decrease with depth. Phosphoric acid, calcium and potash are low at the surface and increase with depth. A reverse tendency is shown by magnesia.

Type 3. HCl-solubles increase with depth because of increase in the clay and calcium contents. Except in the second depth, sesquoxides increase with depth evidently as a result of increase in clay. Almost a similar trend is shown by alumina and iron oxide. Phosphoric acid and magnesia show somewhat even distribution while potash is high in the sub-soil.

Type 4. HCl-solubles are low as compared to the types described above presumably owing to sandy nature of the profile. From the second layer they increase with depth evidently as a result of increase in calcium and also partly due to increase in clay. Alumina also shows a similar trend while iron oxide is almost evently distributed throughout the profile. Other mineral constituents show uneven distribution owing to sandy nature of the profile.

TABLE 7

Clay Analyses

(Per cent on ignited basis)

Profile No.	Depth in inch	SiO_2	R_2O_3	Al_2O_3	Fe_2O_3	TiO_2	MgO	CaO	K_2O	B.E.C.* T.B.	Molecular ratios SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3
1	0–13	52.30	35.33	14.56	19.65	1.20	7.12	1.50	1.94	125	3.28	6.13	7.13
	13–25	51.01	37.31	18.68	17.62	1.01	8.02	1.30	1.72	118	2.87	4.64	7.66
	25–38	53.00	35.00	11.67	22.00	1.33	8.03	1.20	2.34	109	3.06	7.74	6.46
	38–60	48.40	35.64	17.20	17.82	0.62	9.92	3.66	2.16	115	2.95	4.97	7.26
2	0–14	50.83	36.69	17.91	18.49	1.20	4.12	2.87	4.21	59	2.92	4.84	7.35
	14–29	50.55	37.71	17.16	20.34	1.01	4.26	3.39	3.78	58	2.85	5.01	6.63
	29–43	51.90	35.18	17.86	16.98	1.33	5.35	3.69	2.99	61	3.06	4.91	8.16
	43–62	52.70	35.60	16.34	18.34	0.62	5.42	4.60	2.42	63	3.14	5.46	7.50
3	0–6	57.62	32.67	11.99	20.39	0.29	4.88	1.33	1.92	69	3.52	8.20	7.55
	6–20	54.81	31.89	17.44	14.18	0.27	6.18	3.40	2.40	69	3.47	5.21	10.37
	20–39	52.88	34.24	14.62	19.41	0.21	7.57	3.54	1.17	58	3.33	6.16	7.28
	39–60	52.23	34.67	18.81	15.54	0.32	8.70	5.24	1.50	57	3.09	4.72	8.96
4	0–8	51.99	37.02	18.18	18.12	0.72	7.97	1.20	0.87	59	2.97	4.97	7.66
	8–22	50.82	37.28	9.53	27.22	0.53	8.80	1.90	0.92	59	3.22	9.10	4.98
	22–43	54.95	37.12	20.00	16.63	0.49	4.25	0.87	1.03	48	3.05	4.66	8.88
	43–55	54.70	39.57	22.32	16.85	0.40	2.09	1.82	0.69	68	2.82	4.17	8.67
	55–62	52.34	36.18	22.93	12.86	0.39	6.11	3.10	0.73	56	2.86	3.89	10.90
	62–72	51.07	35.87	21.41	14.16	0.30	5.89	3.80	0.72	57	2.19	2.84	9.67

*Total base exchange capacity

Type 1. Except in the third layer where accumulation of silica is slightly higher, it decreases with depth. The content of sesquioxide is high in the second layer while in others it is somewhat constant. Alumina and iron show uneven distribution with a tendency of deposition of alumina in the second and that of iron oxide in the third layer. Magnesia, potash and calcium sow analogous behaviour in that they are low at the surface and increase with depth. It seems probable that dibasic and potassic minerals of the parent material have been subjected to the greatest amount of disruption. The SiO_2/R_2O_3 and SiO_2/Fe_2O_3 ratios vary from 2·87 — 3·28 and 6·46 — 7·66 respectively. Further they give an indication of relative accumulation of iron oxide in the third layer. The exchange capacity is high and with the exception of third layer, it decreases with depth. The ratios and exchange capacities suggest the clays to be of montmorillonitic nature.

Type 2. The content of silica increases with depth. Sesquioxides are high in the first two layers while alumina remains almost consant throughout the profile. Iron oxide shows a tendency to accumulate in the second and fourth layers. Magnesia and calcium increase with depth while potash shows a reverse trend. This evidence appears to suggest that the constituents subjected most to weathering and disruption are silicates of iron and magnesium. The exchange capacity shows the same order as silica. SiO_2/R_2O_3 ratio increases with depth while those of SiO_2/Al_2O_3 and SiO_2/Fe_2O_3 are relatively constant. These values give an indication of dominance of montmorillonitic type of clay minerals in the soil.

Type 3. Silica is high in the surface layer and decreases with death, the average figure being 54·38. With exception of the second layer, sesquioxides shows reverse order. Alumina shows a tendency of deposition in the second and fourth layers. Calcium and magnesia increase with depth. The SiO_2/Al_2O_3 ratio give an indication of relative accumulation of alumina in the sub-soil. The molecular ratios, in general, are wide and the exchange capacity varies from 57·8 — 69·5 milliequivalents per 100 gm. These facts point out that the soil complex is much weathered material with montmorillonite as the dominant clay mineral.

Type 4. Silica is high in the third and fourth layers while its average figure for all the layers is 52·64. A similar tendency is also shown by sesquioxides, the

average figure being 37·17 Magnesia tends to accumulate near the surface while calcium shows a reverse trend. The SiO_2/Al_2O_3 and SiO_2/Fe_2O_3 ratios show wide variations, the ranges being from 2·84-9·1 and 4·98-10·90 respectively. The relative abundance of the mineral constituents in the sub-soil is possibly due to sandy nature of the profile. The exchange capacity varies from 57·0 — 68·7 milli-equivalents per 100 gm. The molecular ratios and the exchange capacity data suggest the preponderance of montmorillonitic type of clay minerals in this soil also.

Soil types 1 — 3 of Kapasan show marked morphological and pedochemical variations, although they have been obtained from area with in a radius of about 2 miles. It seems probable that topographical variations leading to the differences in the degree of weathering undergone by the soil complex might have been responible for marked variations in their pedochemical characteristics. The profile differentiations into well marked horizons is absent and this is confirmed by the results of clay analyses. Type 4 is representative of the arid zone where soil formation is restricted much in intensity.

The occurrence of 'kankar' nodules of varying size and consistency is almost universal in all the types reported. All the soils, in general, contain fair amount of mineral plant nutrients. Partially sodium saturated clay when highly dispersed is liable to translocation downward through the soil is well exemplified by type 3 which shows highest accumulation of it in the bottommost layer. The land is subjected to floods during the rains and the adjacent land is canal irrigated. These two factors seem to have led to the accumulation of alkaline salts in the soil type.

Type 4 shows relatively more uneven distribution of mineral constituents, organic carbon and nitrogen due to the sandy nature of the profile. Of interest is to note the remarkably narrow C/N ratio in the case of type 4. This indicates that the decomposition processes have depleted the organic reserve of the soil more of its organic carbon evidently as results of seasonal sparse rainfall and high temperatures throughout the major period of the year. Somehow nitrogen of the organic matter seems to have been retained by the mineral colloids to a greater degree and thus relatively accumulated in the soil. Some insite into the weathering processes undergone by the soil complex is obtained by an examination of the clay composi-

tion. The present evidence suggests the preponderance of montmonillonitic type of clay minerals in all the soil types studied.

ACKNOWLEDGEMENTS

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III. A MINERALOGICAL STUDY OF THE FINE SANDS AND ROCK FRAGMENTS OBTAINED FROM SEVEN TYPICAL SOIL PROFILES OF RAJASTHAN

By

S. SINGH *and* G. S. BHANDARI

Agriculture College, Banaras Hindu University Varanasi-5

ABSTRACT

The mineral constituents of the fine sands obtained from seven different soil profiles of Rajasthan have been examined. The rock fragments and pebbles encountered in the profiles have also been examined for their mineral makeup.

The soils under study vary remarkably in their physico-chemical properties and colour. The present evidence suggests their parentage to quartzites, gneisses, schists and acid igneous (volcanic) rocks. Further, a comparison of the local geological formations with that of the mineral constituents of the fine sands and rock fragments obtained from these different profiles suggests the formation of almost all the Udaipur and Kapasan (Chittorgarh) region soils *in situ*, the transported character of the Kota region soils and the old aeolian origin of Jodhpur region soils.

Mineralogical study of the coarser soil fraction, bedrock and rock fragments encountered in the soil profile is gaining increasing importance. This is owing to the fact that such a study makes possible, (a) to draw distinction between the soils formed *in situ* and the transported soils ; (b) elucidation of the genesis of soil from its mineral components ; (c) correlation and differentiation of soils in a particular area and (d) to judge potential fertility of soils.

With these points in view a mineralogical study of the fine sands obtained from seven different soil profiles of the State was carried out and is reported in the present paper which is tenth of a series (Singh and Bhandari[1to9]). The study was supplemented with the examination of thin sections of the rock pieces and pebbles encountered in these profiles.

GEOLOGICAL FEATURES

Rajasthan comprises vast and geologically diverse land area. An unique feature is the Aravalli mountain range, probably the oldest geological formation in the world, which bisects the State from south-west to north-east, extending up to Delhi. The south-eastern part of the State is constituted of plateau (Kota and Chittorgarh) and hilly tracts (Udaipur). Udaipur region is characterised mostly by quartzite ridges which are considered to belong to the Alwar group of Delhi system. With them are associated bands of conglomerate containing boulders and pebbles of quartz and a large area of granite gneiss. Schists, sandstones and limestones are also of common occurrence.

The great antiquity and diverse physiography of Chittorgarh region render it difficult for any well authenticated theory regarding its geolozical formation. The region is mainly constituted of quartzite, conglomerate, talc-schist, hornblende, Chlorites, granite-gneiss, sandstones and limestones. The main feature of Jodhpur

area is that it is mostly convered by sand dunes but in the plains isolated hills of solid rocks are scattered. Schists of the Aravalli system upon which rests unconformably ancient sub-aerial rhyolites and bands of conglomerate are the main geological feature of the area.

EXPERIMENTAL

A brief description of the profiles is given in Table 1. Fine sand fractions

TABLE 1

A brief description of soil profiles.

Profile No.	Locality	Depth in inch	Soil	pH
1	Kota	0- 8	Very dark grey clay loam	7·8
		8-32	Dark grey clay loam	7·8
		32-45	Light grey clay loam	7·9
		45-55	Light grey clay loam	8·1
		55-72	Light grey clay loam	8·2
2	Udaipur	0-12	Dark reddish brown clay loam	6·9
		12-24	Reddish brown clay loam	7·0
		24-36	Reddish brown clay loam	7·0
		36-60	Reddish brown clay loam	6·9
3	Udaipur	0- 9	Very dark grey sandy loam	7·9
		9-20	Dark grey sandy loam	7·8
		20-39	Light grey sandy loam	8·2
		39-72	Light yellow sandy loam	8·3
4	Kapasan	0-13	Very dark grey clay loam	7·2
		13-25	Dark grey clay loam	7·2
		25-38	Dark grey clay loam	7·8
		38-60	Grey clay loam	7·6
5	Kapasan	0-14	Very dark reddish brown loam	7·3
		14-29	Dark reddish brown loam	7·4
		29-43	Dark reddish brown loam	7·4
		43-62	Reddish brown loam	7·8
6	Kapasan	0- 6	Pale yellow sandy loam	9·2
		6-20	Pale yellow loam	8·9
		20-39	Pale olive loam	8·4
		39-60	Pale olive loam	8·2
7	Jodhpur	0- 8	Yellowish brown sandy	7·2
		8-22	Yellowish brown sandy	7·2
		22-44	Yellowish brown sandy	7·5
		44-55	Yellowish brown sandy	7·7
		55-62	Pale brown sandy loam	7·8
		62-72	Pale brown sandy loam	7·9

(0·2 – 0·02 mm.) obtained during the mechanical analysis of soils by the international pipette method were taken for study. 40 mg. portion of the fine sand fractions were mounted on slides with Canada Balsam, and permanent mounts have been prepared in the usual fashion.

Soils of profiles 1, 3 and 4 are dark grey in colour and no stone pieces or pebbles were found at any depth of sampling. However, the bottommost layers of profiles 1 and 3 were highly calcareous. Stone pieces and pebbles were found in the 3rd and 4th layers of profile 2, in the 2nd, 3rd and 4th layers of profile 5, in the 2nd and 4th layers of profile 6 and in the 1st, 2nd and 6th layers of profile 7. Stone pieces and pebbles differing in colour and external features were encountered in the same layer of some of the profiles and all these were included in the study. The size of these fragments and pebbles varied from 1 – 3·5 inches. permanent slides of their thin sections were prepared by the conventional procedure employed for preparing rock slides.

RESULTS AND DISCUSSION

Mineralogy of the rock fragments and pebbles

Profile 2.—3rd layer—In the hand specimens the pebbles look like pieces of vein quartz but the thin section under the microscope appears to be that of sandstone in which quartz grains of fine and medium size and all of irregular shape (not rounded) are huddled together without any cementing material. The quartz grains do not appear to be of Archaean origin.

4th layer—Quartz—Probably of Archaean age, intersected by vienlets of quartz of comparatively recent origin. The former shows undulating extinction under the microscope.

Profile 5.—2nd layer—Composed mostly of medium-size grains of quartz together with finer-grained ones. Other minerals are biotite, chlorite (altered from biotite) and a few grains of plagioclase feldspar.

2nd layer—(Another specimen) Feldspathic sandstone, age indeterminable. The specimen is weathered and has not yielded a good section.

3rd layer—Sandstone in which bigger crystals of quartz and feldspar (plagioclase) lie embedded in a matrix of fine-grained quartz. The grains are not rounded, are of varying size and are unassorted. The rock might be of aeolian origin. Age indeterminable.

4th layer—Larger grains of quartz, derived from metamorphic rocks, together with small grains of quartz of later origin, possibly igneous. Belongs to the Archaean system.

4th layer—(Another specimen) same as above with some grains of quartz.

4th layer—(Third specimen) Appeared to be a fine-grained clay in which no mineral form could be recognised.

4th layer—(Fourth specimen) Fine—grained concretionary limestone which shows few grains of quartz, biotite and feldspar. Recent origin.

Profile 6.—2nd layer—Actinolite—schist in which the dominant constituent is actinolite (a variety of hornblende), the other constituent being quartz. Belong to Dharwar system.

4th layer—same as above.

Profile 7.—1st layer—Sandstone made up completely of quartz grains which are of irregular shape and varying size.

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. 1st layer—(Another specimen) Made up of angular grains of quartz and flakes of muscovite embedded in a groundmass or cementing material which could not be determined.

1st layer—(Third specimen) Rhyolite in which corroded grains of quartz and a few of feldspar are embedded in a glassy groundmass which has undergone partial devitrification. A small crystal of augite is also seen. There are some black patches here and there. These may be alteration products of some other minerals. Belongs to the Vindhyan system.

2nd layer—(Another specimen) Similar to the first specimen. May be a rhyolite and/or tuff. Shows also a grain of muscovite.

2nd layer—(Third specimen) An acid tuff in which corroded grains of quartz and pieces of other rocks and minerals (altered) are embedded in a glassy groundmass. Probably of Vindhyan age.

6th layer—Quartzite. It may be a product of metamorphism of sandstone or may be a quartz vein.

Mineral Constituents of the Fine Sand Fractions

The relative abundance of the mineral constituents of fine sands from different layers of all the profiles is shown in Table 2. The fine sands were clean enough for optical xamination. In the case of the fine sands obtained from profiles 1, 4 and 6, the mineral grains were too small to be satisfactorily examined with a quarter inch objective. So only such minerals have been recorded as were comparatively easy to recognize. Similarly, many constituents which are not present in abundance and whose characters are not conspicuous, might have been missed and thus not recorded.

TABLE 2

RELATIVE ABUNDANCE OF MINERAL CONSTITUENTS IN FINE SAND FRACTION

SOIL PROFILES

MINERALS / DEPTHS	I 1	2	3	4	5	II 1	2	3	4	III 1	2	3	4	IV 1	2	3	4	V 1	2	3	4	VI 1	2	3	4	VII 1	2	3	4	5	6
QUARTZ	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
ACTINOLITE	●	○	I	I	I	○	I	I	I	●	●	●	●	●	●	●	●	○	○	●	○	○	○	○	○	●	●	●	●	●	○
TOURMALINE	○	○	○	○	○	I	I	○	I	○	○	○	○	I	I	I	I	I	I	·	I	○	○	○	○	I	I	I	I	○	I
EPIDOTE	●	○	○	I	○	○	○	○	○	I	I	○	○	I	○	○	●	○	○	○	○	○	○	○		○	I	I	I	I	I
TREMOLITE	·	I	·			I	I	·	I	I	I	·	I	○	·	·	·		·	I	I	·		·	I	·	I	·		·	○ ○
GARNET	○	I	I	I	I		I	I	·	I				I	·	I	I	I	I	I	·	○	○	I	I	○	I	·	I	○	○
CHLORITE						·	·	·	·	●	○	○	○	·	I	·	·	○	○	○	○	●	○	I	I	·	I	○	I	·	·
TOPAZ							·			·				·					·	·			·	·		·	I	·	·	·	·
ZOISITE	·	·	I		·						·	I	I	I	I	·	I	●	●	●	●		·	I	·	·	·		I	·	·
BIOTITE	○	○	○	○	●	○	○	○	●	●	●	●	●	●	○	●		●	●	●	●	●	●	●	●	·	I	·	·	I	I
MUSCOVITE	·	I		·	·	·	·	·	I	·	·	·	○	·	I	·	·	·	I	○	○	●	○	○	I	○	·	·	·	·	·
ZIRCON										·	I	·	·	·	·											·	·	·			
DUMORTIERITE	·	I	·	.	·																			·		·	·	I		I	·
STAUROLITE						·	·	I		·	·	·	·	·	·	I	·	I	I	I	I	○	I	·	I	·	I	I	·		·
APATITE										○	○	I	I			I		I	I			I	I	I	I						
SILLIMANITE	I	I	I		I																		·					·			
PLAGIOCLASE						·	I	·	·	·								I	·	I	I		·				·				

⊙ > 100 ⎫
● > 20 ⎪ Number of individual grains
○ 7-20 ⎬ seen in a comparative –
I 2-6 ⎪ survey of the slides.
· 1 ⎭

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Quartz is the predominant constituent of all the sands examined. Actinolite and biotite are present in abundance next to quartz. Actinolite is abundant in almost all layers of profiles 3, 4 and 7. Profiles 4, 5, 2 and 1 come next in order of its abundance in them. Biotite is very abundant in all layers of profiles 3-6, relatively less in profiles 1 and 2 and frequent in profile 7. Tourmaline and epidote are other abundant mineral constituents except that the former is relatively less abundant in profiles 4, 5 and 6 and the latter in profile 7. Tremolite, garnet and chlorite come next in relative occurrence, except that tremolite in profile 4, garnet in profile 3 and chlorite in profile 1 could not be observed. Apatite and staurolite have been found in all the layers of profiles 3-6. One to two grains of plagioclase could be observed in all the layers of profiles 2 and 5.

Biotite is in most cases partly altered. Actinolite is often altered or partly altered to chlorite. Even when it is partly altered, it is taken as actinolite. Epidote, zoisite and clinozoisite belong to the same group of minerals. Due to the fragmental nature of the grains a distinction between zoisite and clinozoisite could not be made. Tremolite belongs to the same group of minerals as actinolite— characters of one grades into the other. Grains, laths and prisms which are colourless, have been taken as tremolite and those showing green or bluish green colour as actinolite.

The predominance of quartz and presence of biotite, actinolite, tourmaline, epidote, garnet, chlorite, and muscovite, in order of relative occurrence in all the sands examined suggest the formation of these soils in somewhat similar conditions. The absence of minerals like ilmenite, magnetite, titanite, leucite, leucoxene and pyroxene in all the sands confirm their non-parentage to trappean or basaltic.

Biotite which is relatively less resistant to weathering, is present in abundance in almost every layer of types 1-6. It seems probable that the abundance of magnesia, calcium and sesquioxides in almost all types is owing to inherently high proportions of minerals like acrinolite, garnet and biotite in them. In case of the fine sands obained from types 1, 4 and 6 the mineral grains were too small and rounded. Further, relatively finer mineral grains occured in surface layers suggesing advance degree of weathering with increasing proximity to surface. This is presumably owing to greater leaching incident to the surface. Occurrence of few grains of plagioclase in fine sands of reddish brown soil types 2 and 5 can possibly be taken as an indication of comparatively younger soils or of the addition of recent material to old soils.

Profile 1—sampled from Govt. Agr. Farm Kota (Vill. Borkheda is typical of the dark grey alluvium of the region. The mineral constituents of the fine sands neither show ferromagnesian minerals or trappean or basaltic origin nor are they in conformity with the local geological formations. It is suggested that owing to the relatively unstable nature, these minerals might has disappeared as a result of their long transportation by rivers flowing from the site of their origin. A similar study of the four soil profiles of Kota region by Tamhane and Rao[10] have also led to a similar conclusion.

Profiles 2 and 3 are representatives of the reddish brown and dark grey soils found at a distance of 7 and 10 miles respectively to the west of Udaipur along the Jaisamand road. It is seen from Table 2 that the dark grey soil shows relatively greater abundance of actinolite, biotite and chlorite in all the layers than in the brownish and red soil profile. Almost the same mineral constituents in the fine sands of these soils are indicative of their common parentage to quartzites, geneisses

and schists. The topography of the local land is not level but gently sloping southwards. The second soil type which is dark grey in colour is representative of the land at lower elevation. Almost a similar assemblage of mineral constituents, as in reddish brown soil, might have given rise to the montmorillonitic type of clay minerals (as reported in our earlier at studies) in an alkaline environment which probably have been conducive to the formation of characteristic clay-humas complexes to which the dark grey colour of these soils might be attributed. The mineral constituents of rock fragments and the fine sands obtained from these two profiles conform with the local geological formations suggesting the origin of these soils *in situ*. No rock fragments could be found in soil profile 5 of low elevation and therefore it has not been possible to correlate the mineral constituent of fine sands with those of the original bed-rock. However, it is deduced that at the surface some transported material might have got mixed up.

Profile 4–6 are representatives of the typical 'Bhuri', 'Kali', 'Bhuri' and 'Urdi' soils of the Chittorgarh region. The fine sands and rock fragments obtained from these soils show somewhat similar mineral constituents, although the proportions of individual minerals vary in them. This is indicative of their common parentage to metemorphic rocks. And it seems probable that the marked differences in the degree of weathering of the soil complex under different topographical conditions might have been responsible for quantitative variation in their mineral make up. Further, the mineral constituents appear to be the same as are known to be present in the bed rocks underlying the soil and are thus concluded to have formed *in situ*.

Profile 7 is representative of the soils of Jodhpur region (Vill. Mandore). The mineralogy of the fine sands and the rock fragments encountered in the profile confirm the parentage of these soils to acid igneous (volcanic) rocks, quartzites and other metamorphic rocks. This and the local geology suggests these soils to be of old aeolian origin.

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A RELATION BETWEEN HANKEL TRANSFORMS OF DIFFERENT ORDER

By

B. R. BHONSLE

Govt. Engineering College, Jabalpur (M.P.)

and

K. N. SRIVASTAVA

M. A. College of Technology, Bhopal (M.P.)

ABSTRACT

In this paper a relation between Hankel transforms of different orders has been obtained. A special case of the theorem proved here is used in the evaluation of certain integrals involving Jacobi polynomials.

I. Introduction

The Hankel transform of a $f(t)$ is defined by the equation

$$(1\cdot1) \quad \mathscr{H}_2\left\{f;\xi\right\} = \int_0^\infty t f(t) J_\nu(\xi t)\, dt, \xi > 0.$$

The object of this note is to obtain a relation between

$$\mathscr{H}_\nu\left\{f;\xi\right\} \text{ and } \mathscr{H}_\mu\left\{t^k f(t);\xi\right\}$$

where $0 < k < 2$, but when

$\mu = \nu + 2m + k$, we can have $k > 0$.

2. Results required in the proof

We have [2, p 349]

$$(2\cdot1) \quad \int_0^\infty x^{\rho-1} J_\mu(ax) J_\nu(bx)\, dx =$$

$$= \frac{2^{\rho-1} a^\mu b^{-\mu-\rho} \Gamma\left(\frac{\mu+\nu+\rho}{2}\right)}{\Gamma(\mu+1) \Gamma\left(\frac{2-\mu+\nu-\rho}{2}\right)} \times$$

$$\times \, _2F_1\left[\frac{\mu+\nu+\rho}{2}, \frac{\mu-\nu+\rho}{2}; \mu+1; a^2/b^2\right]$$

$\operatorname{Re}(\mu+\nu+\rho) > 0$, $\operatorname{Re}(\rho) < 0$, $0 < a < b$.

If m is zero or a positive integer, $\nu > -m-1$ and $k > 0$ then [4]

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$$(2.2) \quad I\left(\nu, m, k, r\right) = \int_0^\infty x^{1-k} \, J_{\nu+2m+k}(x) \, J_\nu\left(rx\right) dx =$$

$$\left\{ \frac{\Gamma\left(\nu+m+1\right)}{2^{k-1}\,\Gamma\left(\nu+1\right)\,\Gamma\left(m+k\right)} \, r^\nu \, \left(1-r^2\right)^{k-1} \, \mathcal{J}_m\left(\nu+k, \nu+1, r^2\right) (0 < r < 1) \right.$$

$$= 0 \, (r > 1)$$

where $\mathcal{J}_m\left(\nu+k, \nu+1, r^2\right)$ being Jacobi's Polynomial (3)

3. Theorem

Let

(i) $\quad \mu > -1,$ and $0 < k < 2$

(ii) $\quad \displaystyle\int_0^\infty t^{\frac{1}{2}+k} \, |f(t)| \, dt$ and

$$\int_0^\infty t^{\mu+k+1} \, |f(t)| \, dt$$

are convergent, and

(iii) $\quad \displaystyle\int_0^\infty y \, \mathscr{H}_\mu\left\{ \xi^k \, f(\xi) \, ; \, y \right\} dy$

is absolutely convergent, then

$$(3.1) \quad \mathscr{H}_\nu\left\{ f, x \right\} = \int_0^\infty y \, \mathscr{H}_\mu\left\{ \xi^k \, f(\xi); \, y \right\} k\left(x, y\right) dy$$

where

$$r\left(x, y\right) = \frac{2^{1-k} \, y^\mu \, x^{k-\mu-2} \, \Gamma\left\{ (\mu+\nu+\rho)/2 \right\}}{\Gamma\left(\mu+1\right) \Gamma\left\{ (2-\mu+\nu-\rho)/2 \right\}} \times$$

$$\times \, {}_2F_1\left[\frac{\mu+\nu-k+2}{2}, \frac{\mu-\nu-k-2}{2}; \mu+1; y^2/x^2 \right], \, (0, < y < x)$$

$$= \frac{2^{1-k} \, x^\nu \, y^{-\nu+k-2} \, \Gamma\left\{ (\nu+\mu-k+2)/2 \right\}}{\Gamma\left(\nu+1\right) \Gamma\left\{ (\mu+k-\nu)/2 \right\}} \times$$

$$\times \, {}_2F_1\left[\frac{\nu+\mu-k+2}{2}, \frac{\nu-\mu-k+2}{2}; \nu+1; x^2/y^2 \right], \, (y > x).$$

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Proof: If $\mu > -1$ and the conditions in (ii) are satisfied then by Hankel's inversion theorem (1), we have

$$t^k f(t) = \int_0^\infty y\, J_\mu\,(yt)\; \mathcal{H}_\nu\left\{ \xi^k f(\xi); y \right\} dy.$$

Hence

$$\mathcal{H}_\nu\left\{ f; x \right\} = \int_0^\infty t^{1-k} J_\nu\,(xt)\, dt \int_0^\infty y\, J_\mu\,(yt)\; \mathcal{H}_\mu\left\{ \xi^k f(\xi); y \right\} dy =$$

$$= \int_0^\infty y\; \mathcal{H}_\mu\left\{ \xi^k f(\xi); y \right\} dy \int_0^\infty t^{1-k} J_\nu\,(x\,t)\, J_\mu\,(y\,t)\, dt$$

$$= \int_0^\infty y\; \mathcal{H}_\mu\left\{ \xi^k f(\xi); y \right\} k\,(x, y)\, dy.$$

The change of the order of integration is justified under the conditions mentioned in the theorem.

4. Corollary: When $\mu = \nu + 2m + k$ and m is zero or a positive integer $\nu > -m - 1$ and $k > 0$ and condition (ii) and (iii) of the above theorem are satisfied then

(4.1)
$$x^{-k}\, \mathcal{H}_\nu\left\{ f; x \right\} = \frac{1}{2^{k-1}} \frac{\Gamma\,(\nu+m+1)}{\Gamma\,(\nu+1)\, \Gamma\,(m+k)} \times$$

$$\times \int_0^1 t^{-\nu-k-1}\,(1-t^2)^{k-1}\, \mathcal{F}_m\,(k+\nu,\, \nu+1,\, t^2) \times$$

$$\times \mathcal{H}_{\nu+2m+k}\left\{ \xi^k f(\xi); x/t \right\} dt.$$

This result follows because of (2.2)

5. Example :

$$f(t) = t^{\mu-2}\, e^{-pt^2},$$

then from the Hankel transform table [5] and (4.1) we have

$$\int_0^1 t^{-(2k+2m+1)}\,(1-t^2)^{k-1}\, \mathcal{F}_m\,(k+\nu,\, \nu+1,\, t^2) \times$$

$$\times {}_1F_1 \left[\; \nu + \mu + 2m + 2k \; ; \; \nu + 2m + k + 1 \; ; \; - \frac{x^2}{4pt} \; \right] dt \; =$$

$$= \frac{2^{2m+2k-1} \; p^{k+m} \; \Gamma(\mu + \nu/2) \; \Gamma(\nu + 2m + k + 1) \; \Gamma(m+k)}{\Gamma\{(\mu + \nu + 2m + 2k)/2\}} \times$$

$$\times {}_1F_1 \left[\; \frac{\nu + \mu}{2} \; ; \; \nu + 1; \; - x^2/4p \; \right],$$

provided $p > 0$, $\nu > -m - 1$, $k > 0$ and m is zero or a positive integer.

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RETARDING EFFECT OF PHOSPHATES AND PADDY STRAW ON NITROGEN LOSS IN THE NITRIFICATION OF OIL CAKES

By

N. R. DHAR *and* G. SINGH

Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad

ABSTRACT

In the nitrification of the proteins present in neem cakes, ground nut cakes and castor cakes at 36°C, the following changes take place : Proteins $\rightarrow$ aminoacids $\xrightarrow{+O_2}$ $NH_3 \xrightarrow{+O_2}$ $NO_2 \rightarrow NO_3$. As an intermediate product there is always the formation of the unstable substance ammonium nitrite.

This undergoes oxidation and decomposition as in the equations: $2NH_4NO_2 + O_2 \rightarrow 2NH_4 NO_3$, $NH_4 NO_2 = N_2 + 2H_2O + 718K$. Cal. The decomposition is more prominent than the oxidation to nitrate. Carbohydrates in Paddy Straw slowdown the nitrification and hence decrease nitrogen loss. Mineral phosphates including basic slags create nitrites of Na, K and Ca, which are stabler than ammonium nitrite and nitrogen loss decreases.

From ancient times, animal and plant materials like blood, fish, bonemeal, tankage, wool residue, meat residue, guano, human excreta, oil cakes, soot, garbage etc. have been used as manure. But the mechanism of their action has been cleared up only in recently years. When they are mixed with soil, the carbonaceous compounds and proteins are slowly oxidised with the liberation of carbon dioxide and ammonia, which, in turn, is further oxidised to nitrite and nitrate. But a good deal of the fertilizing principle is wasted away as nitrogen gas without benefit either to the orop or the soil. According to Niklewski (1), Russell and Richards (2), Shutt (3), Wyllie (4), Shrikhande (5), Martin and Wang (6) there is a huge loss of nitrogen during the decomposition of proteinaceous materials. Hence the causes of this loss and finding out ways and means of checking the loss in order to preserve the value of compost for land productivity have to be investigated. Moreover, in practical agriculture the recovery of nitrogenous fertilizers and manures varies from 25 to 50% of the applied nitrogen.

EXPERIMENTAL

25 gms of powdered oil cake, dried at 105°C and passed through a 60 mesh sieve, were taken in wide-mouthed bottles of equal size. Phosphate was added to the exsent of 0·25%. The effect of paddy straw was also studied. 25 gms of well powdered, dried and passed through a 60 mesh sieve, paddy straw was mixed well with 25 gms of oil cakes. One set of experiment was carried on at 36°C in an electric incubator, fitted with an electric bulb of 60 watt. A similar set was kept in another electric incubator, under identical condition of light and temperature but were covered by a thick piece of black cloth to cut off light. Moisture level was maintained at 40% and the system aerated thrice in a fortnight. Analysis of total carbon and nitrogen were carried on after 50, 70 and 90 days by Robinson-Mac-Lean's method and salicylic acid reduction Kjeldahl method respectively.

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Analysis of oil cakes and paddy straw.

	Neem cake (Azadiractta Indica) %	Ground nut cake (Arachis hypoaea) %	Castor cake (Ricinus communis) %	Paddy straw %
Loss on ignition	92·28	92·20	90·72	86·75
Ash	7·72	7·80	9·28	13·23
HCl insoluble	1·18	2·02	2·84	4·67
Sesquioxfde	0·4765	0·5623	0·4324	2·6334
Fe_2O_3	0·1600	0·2432	0·1420	1·1537
P_2O_5	1·1458	1·4145	1·8002	0·3857
K_2O	2·0648	1·2935	1·4359	1·5346
CaO	1·6080	1·5217	1·7880	2·6854
MgO	0·6243	0·5237	0·7533	0·1163
Total carbon	45·45	39·32	43·04	31·52
Total nitrogen	7·9275	5·7752	4·7952	0·490
C/N ratio	5·7	6·8	8·9	64·2
pH (1 : 10)	8·1	4·2	7·6	—

Analysis of Tata basic slag and Algerian rock phosphate "C"

	Tata basic slag %	Algerian rock phosphate "C" %
SiO_2	33·56	51·76
Fe_2O_3	17·79	...
Total P_2O_5	7·5	24·14
Available P_2O_5	4·21	6·63
Total CaO	34·52	10·56
Total K_2O	...	9·56
Total MgO	5·25	2·18

25 gms Neém cake (Azadiractta Indica) + 40% moisture

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	11·36	1·9819	...	...	...	5·7
50	7·82	1·5162	−0·4657	3·54	−23·5	5·1
70	6·87	1·3180	−0·6639	4·49	−33·5	5·2
90	6·23	1·2005	−0·7814	5·13	−39·4	5·1
COVERED						
0	11·36	1·9819	...	...	...	5·7
50	8·17	1·5578	−0·4241	3·19	−21·4	5·2
70	7·22	1·4151	−0·5668	4·14	−28·6	5·1
90	6·58	1·3022	−0·6797	4·78	−34·3	5·0

25 gms of Neem cake (Azadiractta Indica) + 0·25% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	11·36	1·9819	...	...	...	5·7
50	7·18	1·7580	−0·2239	4·18	−11·3	4·1
70	6·17	1·7263	−0·2556	5·19	−12·9	3·5
90	5·73	1·6906	−0·2913	5·63	−14·7	3·3
COVERED						
0	11·36	1·9819	...	...	...	5·7
50	7·48	1·7798	−0·2021	3·88	−10·2	4·2
70	6·46	1·7580	−0·2239	4·90	−11·3	3·6
90	6·09	1·7322	−0·2497	5·27	−12·6	3·5

25 gms Neem cake (Azadiractta Indica) + 0·25% P_2O_5 as Algerian rock phosphate "C"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
			EXPOSED			
0	11·36	1·9819	...	...	−	5·7
50	7·58	1·7243	−0·2576	3·82	− 13·0	4·3
70	6·54	1·6728	−0·3091	4·82	− 15·6	3·9
90	6·09	1·6411	−0·3408	5·27	− 17·2	3·7
			COVERED			
0	11·36	1·9819	...	...	—	5·7
50	7·76	1·7481	− 0·2338	3·60	− 11·8	4·4
70	6·81	1·7065	−0·2754	4·55	− 13·9	4·0
90	6·46	1·6708	−0·3111	4·90	− 15·7	3·8

25 gms Neem cake + 25 gms paddy straw

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
			EXPOSED			
0	19·24	2·1044	—	—	—	9·1
50	13·45	2·4663	0·3619	5·79	17·2	5·4
70	12·40	2·6599	0·5555	6·84	26·4	4·6
90	11·86	2·7667	0·6627	7·38	31·5	4·2
			COVERED			
0	19·24	2·1044	—	—	—	9·1
50	14·20	2·3862	0·2819	5·04	13·4	5·9
70	13·22	2·5315	0·4271	6·02	20·3	5·2
90	12·76	2·6052	0·5008	6·48	23·8	4·9

25 gms Neem cake + 25 gms paddy straw + 0·25% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	19·24	2·1044	—	—	—	9·1
50	12·03	2·6789	0·5745	7·21	27·3	4·5
70	10·26	3·0177	0·9133	8·98	43·4	3·4
90	9·12	3·1629	1·0585	10·12	50·3	2·8
COVERED						
0	19·24	2·1044	—	—	—	9·1
50	12·61	2·6573	0·5429	6·63	25·8	4·8
70	10·89	2·8640	0·7596	8·35	36·1	3·8
90	9·70	3·0008	0·8964	9·54	42·6	3·2

25 gms Neem cake + 25 gms paddy straw + 0·25% P_2O_5 as Algerian rock phosphate "C"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	19·24	2·1044	—	—	—	9·1
50	12·51	2·5968	0·4924	6·73	23·4	4·8
70	10·86	2·2524	0·8480	8·38	40·3	3·6
90	9·72	3·0829	0·9785	9·52	46·5	3·1
COVERED						
0	19·24	2·1044	—	—	—	9·1
50	12·99	2·5547	0·4503	6·25	21·4	5·0
70	11·66	2·8030	0·6986	7·58	33·2	4·1
90	10·47	2·9145	0·8101	8·77	38·5	3·5

25 gms ground-nut cake (arachis hypoaea) + 40% moisture

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
			EXPOSED			
0	9·83	1·4438	—	—	—	6·8
50	6·83	1·1320	−0·3118	3·00	− 21·6	6·0
70	6·18	0·9905	−0·4533	3·65	− 31·4	6·2
90	5·55	0·9183	−0·5255	4·28	− 36·4	6·0
			COVERED			
0	9 83	1·4438	—	—	—	6·8
50	7·13	1·1522	−0·2916	2·70	− 20·2	6·2
70	6·57	1·0511	− 0·3927	3·26	−27·2	6·2
90	5·88	0·9761	− 0·4677	3·95	−32·4	6·0

26 gms ground-nut cake (Arachis hypoaea) + 0·25% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
			EXPOSED			
0	9·83	1·4438	—	—	—	6·8
50	6·57	1·2951	−0·1487	3·25	−10·3	5·0
70	5·56	1·2663	−0·1775	4·27	−12·3	4·4
90	5·20	1·2446	−0·1992	4·63	−13·8	4·1
			COVERED			
0	9·83	1·4438	—	—	—	6·8
50	6·75	1·3038	−0·1400	3·08	− 9·7	5·1
70	5·75	1·2923	−0·1515	4·08	−10·5	4·4
90	5·48	1·2706	−0·1732	4·35	−12·0	4·3

25 gms ground-nut cake (Arachis hypoaea) + 0·25% P_2O_5 as Algerian rock phosphate "C"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	98·3	1·4438	—	—	—	6·8
50	6·85	1·2619	− 0·1819	2·98	−12·6	5·4
70	5·98	1·2287	−0·2151	3·85	−14·9	4·9
90	5·56	1·2027	—0·2411	4·27	−16·7	4·6
COVERED						
0	9·83	1·4438	—	—	—	6·8
50	7·12	1·2879	− 0·1559	2·71	−10·8	5·5
70	6·15	1·2533	—0·1905	3·68	−13·2	4·9
90	5·75	1·2345	−0·2093	4·08	−14·5	4·6

25 gms ground-nut cake + 25 gms paddy straw

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	17·71	1·5663	—	—	—	11·3
50	12·72	1·8513	0·2850	4·99	18·2	6·8
70	11·76	1·9970	0·4307	5·95	27·5	5·9
90	11·20	2·1254	0·5591	6·51	32·7	5·4
COVERED						
0	17·71	1·5663	—	—	—	11·3
50	13·54	1·8043	0·2380	4·17	15·2	7·5
70	12·72	1·9046	0·3383	4·99	21·6	6·6
90	12·17	1·9531	0·3868	5·54	24·7	6·2

25 gms ground-nut cake + 25 gms paddy straw + 0·25% P₂O₅ as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	17·71	1·5663	—	—	—	11·3
50	11·55	2·0111	0·4448	6·16	28·4	5·7
70	9·82	2·2601	0·6938	7·89	44·3	4·3
90	8·77	2·3729	0·8066	8·94	51·5	3·7
COVERED						
0	17·71	1·5663	—	—	—	11·3
50	12·15	1·9954	0·4291	5·56	27·4	6·1
70	10·37	2·1818	0·6155	7·34	39·3	4·7
90	9·32	2·2476	0·6813	8·39	43·5	4·1

25 gms ground-nut cake + 25 gms paddy straw + 0·25% P₂O₅ as Algerian rock phosphate "C"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	17·71	1·5663	—	—	—	11·3
50	11·85	1·9672	0·4009	5·86	25·6	6·0
70	10·35	2·2178	0·6515	7·36	41·6	4·6
90	9·29	2·3149	0·7486	8·42	47·8	4·0
COVERED						
0	17·71	1·5663	—	—	—	11·3
50	12·38	1·9124	0·3461	5·33	22·1	6·4
70	11·09	2·1035	0·5372	6·62	34·3	5·2
90	10·03	2·2005	0·6343	7·68	40·5	4·5

25 gms castor cake (Recinus communis) + 40% moisture

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	10·76	1·1988	—	—	—	9·0
50	7·91	0·9651	−0·2337	2·85	− 19·5	8·2
70	7·04	0·8596	− 0·3392	3·72	−28·3	8·0
90	6·41	0·7985	−0·4003	4·35	−33·4	8·1
COVERED						
0	10·76	1·1988	—	—	—	9·0
50	8·34	0·9759	−0·2229	2·42	− 18·6	8·3
70	7·50	0·9099	−0·2889	3·26	− 24·1	8·3
90	6·87	0·8308	−0·3680	3·89	− 30·7	8·2

25 gms castor cake (Ricinus Communis) + 0·25% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (−) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (−) in N over total nitrogen in %	C/N ratio
EXPOSED						
0	10·76	1·1988	—	—	—	9·0
50	7·47	1·0970	− 0·1018	3·29	− 8·5	6·8
70	6·51	1·0682	− 0·1306	4·25	− 10·9	6·1
90	6·05	1·0490	− 0·1498	4·71	−12·5	5·8
COVERED						
0	10·76	1·1988	—	—	—	9·0
50	7·81	1·1077	− 0·0911	2·95	− 7·6	7·1
70	6·72	1·0826	−0·1162	4·04	− 9·7	6·2
90	6·40	1·0766	− 0·1222	4·36	−10·2	5·9

25 gms castor cake (Ricinus communis) + 0·25% P_2O_5 as Algerian rock phosphate "C"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (—) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (—) in N over total introgen in %	C/N ratio
EXPOSED						
0	10·76	1·1988	—	—	—	9·0
50	7·91	1·0742	—0·1246	2·85	—10·4	7·3
70	7·07	1·0466	—0·1522	3·69	—12·7	6·8
90	6·53	1·0226	—0·1762	4·3	—14·7	6·4
COVERED						
0	10·76	1·1988	—	—	—	9·0
50	8·24	1·0874	0·1114	2·52	— 9·3	7·6
70	7·25	1·0634	0·1354	3·51	—11·3	6·8
90	6·73	1·0490	0·1498	4·03	—12·5	6·4

25 gms castor cake + 25 gms paddy straw

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Nitrogen increase (+) or decrease (—) (gms)	Carbon oxidised (gms)	Increase (+) or decrease (—) in N over total introgen in %	C/N ratio
EXPOSED						
0	18·64	1·3213	—	—	—	14·1
50	14·32	1·6199	0·2986	4·32	22·6	8·8
70	12·98	1·7401	0·4188	5·66	31·7	7·4
90	12·57	1·8048	0·4835	6·07	36·6	6·9
COVERED						
0	18·64	1·3213	—	—	—	14·1
50	15·03	1·5657	0·2444	3·61	18·5	9·6
70	14·08	1·6489	0·3276	4·56	24·8	8·5
90	13·50	1·6978	0·3765	5·14	28·5	7·9

25 gms castor cake + 25 gms paddy straw + 0·25% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms).	Total nitrogen (gms).	Nitrogen increase (+) or decrease (—) (gms).	Carbon oxidised (gms).	Increase (+) or decrease (—) in N over total nitrogen in %	C/N ratio
			EXPOSED			
0	18·64	1·3213	—	—	—	14·1
50	12·92	1·7771	0·4558	5·72	34·5	7·3
70	11·08	1·9489	0·6276	7·56	47·5	5·7
90	9·94	2·0242	0·7029	8·70	53·2	4·9
			COVERED			
6	18·64	1·3213	—	—	—	14·1
50	13·52	1·7242	0·4029	5·12	30·5	7·8
70	11·71	1·8828	0·5615	6·93	42·5	6·3
90	10·54	1·9489	0·6276	8·10	47·5	5·4

25 gms castor cake + 25 gms paddy straw + 0·25% P_5O_5 as Algerian rock phosphate "C"

			EXPOSED			
0	18·64	1·3213	—	—	—	14·1
50	13·52	1·7375	0·4162	5·12	31·5	7·8
70	11·62	1·9039	0·5826	7·02	44·1	6·1
90	10·52	1·9634	0·6421	8·12	48·6	5·3
			COVERED			
0	18·64	1·3213	—	—	—	14·1
570	14·06	1·6688	0·3475	4·58	26·3	8·4
70	12·40	1·8167	0·4954	6·24	37·5	6·8
90	11·26	1·9105	0·5892	7·38	44·6	5·8

DISCUSSION

The foregoing experimental results show that nitrogen rich materials like oil cakes, when composted alone or mixed with a dose of 0·25% P_2O_b lead to a loss of nitrogen The loss of nitrogen from the sets receiving artificial light is always greater than those kept in the dark. The rate of loss of nitrogen is rapid in the beginning but slows down with the lapse of time. Dhar and coworkers have advanced an explanation for these heavy losses of nitrogen. When nitrogenous

fertilizers or proteinaceous substances like oil cakes undergo oxidation under aerobic conditions, the following changes take place :—

$$\text{Organic matter} \rightarrow \text{Proteins} \rightarrow \text{Amino-acids} \xrightarrow{+O_2} NH_3 \text{ and } NH_4 \text{ Salts, } \xrightarrow{+O_2} NO_2 \xrightarrow{+O_2} NO_3$$
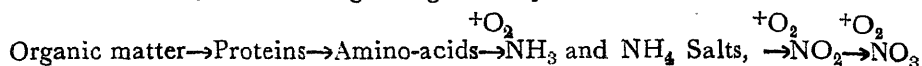
In these processes the unstable substance, ammonium nitrite, is formed as an intermediate product and undergoes oxidation and decomposition aided by light as follows :—

(a) $2NH_4NO_2 + O_2 = 2NH_4NO_3$

(b) $NH_4NO_2 = N_2 + 2H_2O + 718$ K. Cals.
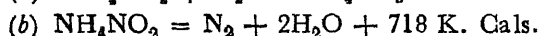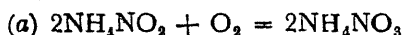
The second chemical change is more prominent than the 1st and, hence, there is considerable loss of nitrogen from different oil cakes.

When a dose of 0·25% P_2O_5 is added to the oil cakes undergoing oxidation, the loss of nitrogen, both in the light and the dark sets, is highly retarded. The retarding effect of these phosphates on nitrogen loss may be explained by the view point that during the process of ammonification and nitrification of proteins, a highly unstable intermediate product is formed, i.e. ammonium nitrite, as explained above. Due to these oxidation processes and decomposition, the amount of protein, and consequently nitrogen in the composts, goes down. But, because of the presence of these phosphates, more or less stable phospho-proteins are formed by the combination of proteins and phosphorus compounds. These compounds seem to resist the ammonification and nitrification and the loss of nitrogen is better checked than with proteins alone.

It has also been observed out that these phosphatic materials can yield larger amounts of Ca^{++}, K^+ and Mg^{++} ions and in presence of these ions $Ca(NO_2)_2$, $Mg(NO_2)_2$ and KNO_2 are formed instead of NH_4NO_2, which are more stable than ammonium nitrite. Thus, conservation of nitrogen of the oil cake composts is observed.

It is well known that the decomposition of ammonium nitrite is accelerated by the presence of acids. When these cakes undergo oxsdation, some acids are likely to be produced in the system which accelerate the decomposition of ammonium nitrite leading to the loss of nitrogen. But in the presence of phosphates, which act as buffer due to the fact that the second and third dissociation contants of phosphoric acid are small, the increase in the H ion concentration of the system is not possible, Hence, the overall effect of phosphates is that they retard the loss of nitrogen considerably.

The above results also show that the incorporation of paddy straw checks the loss and nitrogen is fixed. Perhaps (7) the organic matter acts as a negative catalyst which retards the oxidation of proteins and amino acids. Thus, it appears that cellulosic substances like paddy straw act as protein sparer and enrich the compost in nitrogen content.

Thus, our experiments reveal the fact that the loss of nitrogen which is found in the composting of highly proteinaceous organic materials, can be checked by incorporation of paddy straw and phosphates in the soil.

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EFFECT OF HEAVY DOSES OF NITROGENOUS FERTILIZERS ON THE AMOUNT OF COMPOST PRODUCED DURING THE DECOMPOSITION OF MUNICIPAL WASTE

By

N. R. DHAR *and* G. SINGH

Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad

ABSTRACT

Our experimental results in composting of municipal waste with and without nitrogenous fertilizers show appreciably greater loss of carbonaceous compounds in presence of fertilizers than in their absence. Similar results have been obtained in the composting of wheat straw, Kans, paddy straw etc. These results are not in agreement with those obtained by some American soil scientists. The percentage of N in the fertilized compost is much greater than in the compost without N addition.

The fundamental principle involved in the composting of organic subtances having a C/N ratio greater than 10 to humus with a C/N ratio of 10 is to supply an adequate amount of suitable materials, *e. g.* available nitrogen, phosphate, potash, lime, iron, and air for the growth of micro-organisms which can utilize the energy obtainable from the composting matter. The micro-organisms are believed to decompose the energy material and obtain energy and carbohydrate for building up their body materials. The aim of composting is to decrease the amounts of carbohydrates and save the nitrogenous substances and obtain a material relatively richer in nitrogen and poorer in carbon.

In order to throw further light on the amount of composts obtained at different doses of nitrogenous fertilizers, we have studied quantitatively the effect of heavy doses of the nitrogenous fertilizer like ammonium sulphate on the amount of compost (municipal waste) produced. We have also determined the total carbon, total nitrogen and the total amount of compost (municipal waste) produced after an interval of 30 days and 60 days.

EXPERIMENTAL

100 gms of municipal waste, well powdered, dried at 105°C for 5 to 6 hours, were taken in enamelled dishes of 24 cm. diameter. To some of these dishes only 0·5% P_2O_5 as Tata basic slag and Algerian rock phosphate "A" were added, and to these 0·7 gm. and 1·4 gms of nitrogen as ammonium sulphate alone and along with 0·5% P_2O_5 as Tata basic slag and Algerian rock phosphate "A" were added.

Two corresponding sets of experiments were started. One set was exposed to the light of a 100 watt electric bulb, and the other set, containing the same amount of subtances, was kept covered with a thick piece of black cloth.

After a definite interval of time, composts were weighed and samples were taken out for analysis.

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TABLE 1

Analysis of municipal waste (oven dried) in percent

Loss on ignition	...	... 32·61
Ash	...	... 67·38
HCl insoluble	...	... 52·18
Sesquioxide	...	... 10·16
Fe_2O_3	...	... 3·68
CaO	...	... 1·5272
P_2O_5	...	... 0·8563
Available P_2O_5 (1°/o citric acid solution) ...		... 0·1215
K_2O	...	... 0·7057
MgO	...	... 0·3216
Total carbon	...	... 15·75
Total nitrogen	...	... 0·6356
NH_3-N	...	... 0·0165
NO_3-N	...	... 0·0274
pH (1 : 5)	...	... 8·2
C/N ratio	...	... 25·0

Ammonium sulphate contains 20·5% nitrogen

Analysis of Tata basic slag and Algerian rock phosphate "A"

		Tata basic slag	Algerian rock phosphate
Silica	...	33·56	56·65
Sesquioxide	...	...	...
Fe_2O_3	...	17·79	0·01
Al_2O_3	...	...	...
Total P_2O_5	...	7·57	19·63
Available P_2O_5	...	4·21	7·35
Total CaO	...	34·52	10·65
Total K_2O	...	...	9·02
Total MgO	...	5·25	2·13

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TABLE 2

100 gms municipal waste + 36% moisture

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (—) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
			EXPOSED			
0	15·75	0·6356	...	...	100·00	...
30	12·83	0·7898	2·92	+0·1538	97·23	2·77
60	11·94	0·8288	3·81	+0·1932	96·39	3·61
			COVERED			
0	15·75	0·6356	...	...	100·00	...
30	13·74	0·7544	2·01	+0·1188	98·11	1·89
60	12·81	0·7913	2·94	+0·1557	97·21	2·79

TABLE 3

100 gms municipal waste + 0·5% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (—) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
			EXPOSED			
0	15·75	0·6356	...	...	106·66	...
30	11·91	0·8561	3·84	+0·2205	193·04	3·39
60	10·60	0·8974	5·15	+0·2618	101·77	4·58
			COVERED			
0	15·75	0·6356	...	...	106·66	...
30	12·84	0·7957	2·91	+0·1601	103·91	2·57
60	11·94	0·8370	3·81	+0·2014	101·05	3·38

TABLE 4

100 gms municipal waste + 0·5% P_2O_5 as Algerian rock phosphate "A"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
EXPOSED						
0	15·75	0·6356	...	...	102·54	—
30	12·07	0·8300	3·68	+0·1944	99·05	3·40
60	10·79	0·9675	4·96	+0·2319	97·82	4·60
COVERED						
0	15·75	0·6356	...	...	102·54	...
30	13·05	0·7728	2·70	+0·1372	99·98	2·50
60	12·24	0·8110	3·51	+0·1754	99·21	3·24

TABLE 5

100 gms of municipal waste + 0·7 gm of N as $(NH_4)_2SO_4$

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
EXPOSED						
0	15·75	1·3356	...	...	103·75	...
30	12·27	0·9937	3·48	−0·3419	99·93	3·68
60	11·14	0·9256	4·61	−0·4100	98·73	4·83
COVERED						
0	15·75	1·3356	...	...	103·75	...
30	13·30	1·0632	2·45	−0·2724	101·03	2·62
60	12·48	1·0058	3·27	− 0·3298	100·16	3·46

TABLE 6

100 gms of municipal waste + 1·4 gms of N as $(NH_4)_2SO_4$

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
EXPOSED						
0	15·75	2·0356	...	...	107·51	...
30	12·64	1·3313	3·11	−0·7043	103·70	3·54
60	11·47	1·2051	4·28	− 0·8305	102·40	4·75
COVERED						
0	15·75	2·0356	...	...	107·51	...
30	13·58	1·4962	2·17	− 0·5394	104·81	2·52
60	12·73	1·4087	3·02	−0·6669	103·87	3·38

TABLE 7

100 gms of municipal waste + 0·7 gm of N as $(NH_4)_2SO_4$ + 0·5% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight °/o
			EXPOSED			
0	15·75	1·3356	...	...	110·41	...
30	10·97	1·0605	4·78	−0·2751	105·35	4·58
60	9·66	0·9911	6·09	−0·3445	103·98	5·82
			COVERED			
0	15·75	1·3356	...	...	110·41	...
30	12·05	1·1166	3·70	−0·2190	106·49	3·55
60	10·84	1·0472	4·91	−0·2884	105·22	4·70

TABLE 8

100 gms of municipal waste + 1·4 gms of N as $(NH_4)_2SO_4$ + 0·5°/o P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight °/o
			EXPOSED			
0	15·75	2·0356	...	...	114·17	...
30	11·47	1·3965	4·26	−0·6391	109·29	4·28
60	10·15	1·2499	5·60	−0·7857	107·79	5·58
			COVERED			
0	15·75	2·0356	...	...	114·17	...
30	12·40	1·6039	3·35	−0·4317	110·39	3·31
60	11·25	1·4759	4·50	−0·5597	109·12	4·42

TABLE 9

100 gms of Municipal waste $+ 0.7$ gm of N as $(NH_4)_2 SO_4 + 0.5\%$ P_2O_5 as Algerian rock phosphate "A"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
			EXPOSED			
0	15·75	1·3356	...	...	106·29	...
30	11·27	1·0338	4·48	−0·3018	101·49	4·51
60	9·96	0·9577	5·79	−0·3779	100·13	5·79
			COVERED			
0	15·75	1·3356	...	...	106·29	...
30	12·32	1·1019	3·43	−0·2337	102·63	3·44
60	11·12	1·0338	4·63	−0·3018	101·36	4·63

TABLE 10

100 gms of municipal waste $+ 1.4$ gms of N as $(NH_4)_2SO_4 + 0.5\%$ P_2O_5 as Algerian rock phosphate "A"

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	Carbon oxidised (gms)	Nitrogen increase (+) or decrease (−) (gms)	Wt. of M. W. compost (gms)	Loss in weight %
			EXPOSED			
0	15·75	2·0356	...	...	110·05	...
30	11·75	1·3558	4·00	−0·6798	105·37	4·25
60	10·54	1·2379	5·21	−0·7959	104·05	5·45
			COVERED			
0	15·75	2·0356	...	...	110·05	...
30	12·62	1·5512	3·13	−0·4844	106·44	3·18
60	11·57	1·4555	4·18	−0·5801	105·29	4·32

DISCUSSION

The foregoing results show that there is greater loss of organic matter both in presence of nitrogen and phosphate than in their absence, as the maximum loss in weight was 5·82% with 0·7 gm of nitrogen as ammonium sulphate and 0·5% P_2O_5 as Tata basic slag, while with 0·7 gm of nitrogen as ammonium sulphate and 0·5% P_2O_5 as Algerian rock phosphate "A", the loss in weight was 5·79% of the municipal waste compost. The losses in weight with 1·4 gms of nitrogen as ammonium sulphate along with 0·5% P_2O_5 as Tata basic slag and Algerian rock phosphate "A", were 5·58% and 5·45% respectively of the municipal waste composts. But, the loss of solid matter without adding nitrogenous fertilizer is always smaller than in the presence of nitrogenous fertilizers and phosphates.

Moreover, the total nitrogen estimations prove that without nitrogenous fertilizer, there is appreciable nitrogen fixation in the composting of municipal waste, but, in the presence of nitrogenous fertilizers and phosphates, there is marked loss of nitrogen from the system. The results obtained by some American workers show that there is gain in nitrogen in the composting of millet residues without the addition of urea. But, when heavy doses of nitrogen in the form of urea are added, the greater part of the added nitrogen is lost. Hence, it appears, that adding large doses of nitrogenous fertilizers involves heavy loss of nitrogen added and the amount of compost obtained is smaller than the compost obtained in the absence of nitrogenous fertilizers. But the percentage of nitrogen present in the compost obtained by adding nitrogenous fertilizers to organic matter, is greater than in the absence of nitrogenous fertilizer and the nitrogenated compost should be able to produce better crops.

These results do not support the view point of humus increase by adding nitrogen as advocated by Pinck, Allison and Gaddy (1), who believed that residues, high in nitrogen, lose much less weight than the residues low in nitrogen before coming to a reasonably constant figure. They added different weights of urea to 12·5 tons per acre on mature millet residue on loamy sand, and obtained the results recorded below :

Nitrogen added Lbs/Acre	Gain in carbon Tons/acre	Gain in nitrogen Lbs/acre
0	1·25	171
200	1·82	276
400	2·20	300
800	2·89	402

However, our experimental results in composting of the Allahabad municipal waste mixed with ammonium sulphate show appreciably greater loss of carbonaceous compounds in presence of ammonium sulphate than its absence. Hence, our results are not in agreement with those obtained by the above workers. But for the purpose of obtaining compost rich in nitrogen our experiments also show that the addition of nitrogenous fertilizers appreciably increases the total nitrogen content of the compost prepared by adding nitrogenous fertilizers than without adding nitrogenous fertilizers. Dhar and Pande in their recent experiments on composting of *Kans*, wheat straw, paddy straw, Cactus and Jack fruit leaf obtained appreciably smaller amounts of composts in presence of ammonium sulphate, ammonium nitrate, sodium nitrate and urea than in their absence.

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A STUDY ON THE CORRELATION BETWEEN TOTAL EXCHANGE-ABLE BASES AND EXCHANGEABLE CALCIUM OF SOME UTTAR PRADESH SOILS

By

S. K. DE

Chemical Laboratories, University of Allahabad, Allahabad

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ABSTRACT

Total exchangeable bases and exchangeable calcium of sixty-four samples of Uttar Pradesh soils have been determined and their correlation studied statistically. A moderate positive correlation is found to exist between the two values. Regression equations for the two quantities have also been obtained.

The exchange complex of the soil is the seat of multifarious physicochemical activities associated with the phenomenon of plant nutrition. An exchange-complex with its sites filled up with optimum amounts of calcium is, therefore, of greatest importance to the agriculturist.

The nature of cations that would be associated with such a soil-complex is greatly dependent upon the climate, parent material and the kind of artificial treatments. Williams[1] obtained a correlation between the total exchangeable base content and clay and organic matter contents of some calcareous soils. For some cultivated soils of Uttar Pradesh which are mostly of the nature of Gangetic alluvium, it has been observed by the author that the contents of total exchangeable bases and exchangeable calcium are mutually dependent[2]. It was, therefore felt worthwhile to extend this study of correlation statistically to a good number of Utter Pradesh soils so that regressions equations may be obtained for the calculation of either of the values when the other is known.

MATERIALS AND METHODS

The soil samples were collected from different parts of Uttar Pradesh to a depth of $0-6''$. The sixty-four samples collected represent fairly well the soils of Uttar Pradesh. The pH of the collected samples (1:5 ratio) varied between 6·3 to 10·1.

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TABLE 1

The Relation between the Contents of Total Exchangeable Bases and
Exchangeable Calcium of some Uttar Pradesh Soils

Soil Number	Total Exchangeable Bases (α) m. e./100 g.	Texture	pH	Exchangeable Calcium (β) m. e./100 g.
Ad 4	12·4	Sandy loam	10·1	3·8
Ad 6	12·7	,,	9·8	6·8
Ah 4	4·2	,,	6·5	3·1
Ah 3	4·1	,,	6·7	2·5
Ah 1	7·1	,,	6·7	5·4
Ah 2	13·6	,,	8·4	11·7
Ah 8	7·2	,,	9·4	4·6
Ah 9	5·8	Silty loam	8·3	3·2
Ah 6	3·8	Sandy loam	8·1	2·1
Bs 7	10·1	,,	7·9	7·2
Bs 2	11·1	,,	7·7	8·0
Bs 3	11·9	Loam	6·6	7·2
Bs 10	9·6	Sandy loam	8·2	4·9
Bs 15	8·3	,,	7·4	7·2
Bs 1	12·0	,,	6·8	7·9
Bs 4	9·6	Loam	7·3	6·5
Bs 12	12·2	Sandy loam	7·6	8·9
Bs 14	7·8	Loam	6·7	6·3
Bs 6	11·9	,,	7·5	9·7
Bs 8	8·7	Sandy loam	7·8	5·4
Bs 11	6·1	,,	8·1	3·8
By 2	6·1	,,	7·4	4·6
By 6	7·1	,,	7·3	4·9
Ji 2	10·8	Loam	6·6	7·5
Ji 3	25 2	,,	8·8	20·1
Ji 4	40 8	Clay loam	8·2	36·4
Ji 6	11·2	Loam	6·8	7·7
Ji 8	23·8	Clay loam	7·2	20·2

Table 1—(Contd.)

Kr 27	8·8	Loam	6·7	8·1
Kr 31	13·3	,,	7·3	10·9
Kr 29	10·1	,,	6·8	6·8
Kr 30	14·2	,,	6·3	8·3
Kr 28	7·8	Sandy loam	8·1	5·9
Kr 19	10·5	Silty loam	7·3	9·9
Kr 18	19·0	Silty loam	7·6	9 6
Kr 16	19·2	,,	7·3	16·1
Kr 36	6·8	Silt	6·4	5·4
Kr 34	12·2	,,	7·3	7·3
Kr 15	12·7	Loam	7·4	8·4
Kr 35	13·1	,,	7·4	9·3
Kr 32	11·8	Silty loam	7·1	7·1
Kr 33	10·9	,,	7·4	8·7
Kr 17	9·6	Sandy loam	7·5	6·5
Kr 6	25·8	,,	7·8	21·9
Kr 1	11·2	Loam	7·3	8·1
Kr 3	10·9	,,	6·3	8·8
Kr 7	10·1	,,	7·3	6·9
Kr 5	6·2	,,	6·5	5·1
Kr 2	7·1	,,	7·2	6·5
Kr 4	9·8	,,	7·3	8·6
Kr 9	7·2	,,	8·3	6·6
Kr 10	10·4	,,	8·4	9·6
Kr 14	9·1	,,	6·6	6·5
Kr 8	9·2	,,	6·9	6·5
Kr 12	21·2	,,	8·0	15·7
Kr 11	10·1	,,	7·3	6·9
Kr 37	10·3	,,	7·2	8·9
Kr 21	9·1	,,	7·8	7·1
Kr 25	13·2	Sandy loam	7·3	9·7
Kr 26	11·2	,,	7·1	5·8
Kr 22	10·9	,,	7·1	7·2
Kr 20	15·8	Clay loam	7·1	13·8
Kr 23	10·3	Silty loam	7·4	8·6
Kr 24	11·9	Sandy loam	7·3	6·8

In the laboratory, the soil samples were properly mixed and dried in the air (average temperature 32°C) in diffused sunlight for twelve days. All loose organic matter were removed before the air-dried soil-aggregates were broken and pulverised in an agate mortar and passed through a 100-mesh sieve. The pulverised and sieved samples were later stocked in clean and dried bottles for the experiments.

Total base exchange capacity and exchangeable calcium were determined by the usual ammonia absorption method and Hissink's normal sodium chloride method respectively as described by Piper.[3] Texture of the soil samples were determined by the approximate 'feel and touch' method.

RESULTS AND DISCUSSION

On analysing satistically the results incorporated in table, it is seen that there is moderate positive correlation between the values of total exchangeable bases and exchangeable calcium, the coefficient of correlation $(r_{\alpha\beta})$ being ·3979 ± ·0709. This conclusion is also supported by the values obtained for the coefficient of alienation (K = ·9175) and coefficient of forecasting efficiency (E = 8·25%).The value of Fisher's 't' obtained for the observed correlation is 3·2532; the said correlation coefficient is thus significant at P = 0·01 level.

Regressions of total exchangeable bases on exchangeable calcium and vice versa have also been calculated and are expressed by

$$\alpha = 7·0542 + ·5256\,\beta \qquad\qquad\qquad\qquad\text{(i)}$$

$$\beta = 4·9987 + ·3012\,\alpha \qquad\qquad\qquad\qquad\text{(ii)}$$

The regression coefficients obtained for the two values are thus $r\dfrac{\sigma\alpha}{\sigma\beta} = ·5256$ and $r\dfrac{\sigma\beta}{\sigma\alpha} = ·3012$ (σ = the standard deviation). The most probable value of β for any given value of α and vice versa can now be regressed by the expressions

$$(\beta - \bar\beta) = ·3012\,(\alpha - \bar\alpha) \qquad [\bar\alpha = 11·5001] \qquad\text{(iii)}$$

$$(\alpha - \bar\alpha) = ·5256\,(\beta - \bar\beta) \qquad [\bar\beta = 8·4609] \qquad\text{(iv)}$$

It may be pointed out that in the above two equations, the values $r\dfrac{\sigma\alpha}{\sigma\beta}$ and $r\dfrac{\sigma\beta}{\sigma\alpha}$ are actually the tangents of the angles that the lines (iii) and (iv) will make with the axis of X and are thus proper representations for indicating the extent of increase in β for unit increase of α and vice versa. Thus the value $r\dfrac{\sigma\alpha}{\sigma\beta} = ·5256$ signifies that for every change of a unit of the independent variable β, there is a corresponding variation of ·5256 of the dependent variable, α. In the same fashion, for unit increase of α, the independent variable, there is a corresponding change of ·3012 in β, the dependent variable as is evident in the expression, $r\dfrac{\sigma\beta}{\sigma\alpha} = ·3012$. These regular changes of the variable with respect to each other

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have been assumed to have taken place inspite of polymorphic impacts of the soil environment.

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SYNTHESIS OF SOME NEW 9-ANTHRYL-STYRYL-KETONES

By

DINKAR*, S. C. KUSHWAHA *and* J. B. LAL

H. B. Technological Institute, Kanpur

ABSTRACT

Synthesis of new 9-anthryl styryl ketones by the Claisen Schmidt condensation have been reported as well as the effect of temperature and varying proportions of aldehydes, on the yield.

The anthracene skeleton is present in the molecule of many, carcinogenic polycyclic hydrocarbons[1]; some simple anthracene derivatives have also been found to be carcinogenic, such as 9, 10 dimethylanthracene which produces skin epitheliomas in mice by painting[2] and 2 amino-anthracene, which gives hepatomas in mice by injection[3,4]. According to Pincks[5] the ethylenic linkage in a carcinogenic molecule has the property to react with certain cellular constituents through their external double bonds. This theory suggests the preparation of alpha, beta, substituted ethylenic compoumds, containing anthracene as a polycyclic radical. Apart from this, in view of the various activities shown by substituted phenyl styryl ketones, such as synergetic action with D.D.T.[6] stabilisers for vinylidene chloride copolymers[7], light sensitive polymer for photography[8], in the preparation of resist images[9], in supersensitization[10], it also became desirable to study whether these activities would be retained in chalcones analogues prepared from 9-acetyl anthracene.

This paper reports the syntheses of some new alpha-anthryl-beta-substituted phenyl ethylenes derived by the Claisen Schmidt reaction of 9-acetylanthracene with *o-, m-, p-* hydroxy-benzaldehydes, *o-, m-, p-* chlorobenzaldehydes, *o-, p-* tolualdehydes, *o-, m-,* nitrobenzaldehydes, *o-, m-, p-* methoxy-benzaldehydes, *p-*dimethylamino-benzaldehyde, *o-*veratric aldehyde, veratric aldehyde, vanillin, *o-*vanillin, 5-bromo-vanillin, benzaldehyde and furfuraldehyde in the presence of aqueous solution of potassium hydroxide, at 0°C and 60°C.

The yields in cold condensation are better in comparison with condensation at 60°C. This is probably due to the reversible nature[13] of the reaction in hot alkali solution. By taking the substituted aldehydes in excess (1:1·2 mole) of stoichiometric proportion, the dismutation of these into a mixture of substituted benzyl alcohol and benzoic acid according to Cannizzaro's reaction, also increased at 60°C. The recovery of the products obtained in the cold condensation of *o-, m-, p-* nitrobenzaldehydes was better in the presence of aqueous potassium hydroxide solution (3·0 gm. in 15 cc water). Hot condensation leads to the dismutation of substituted benzaldehyde resulting in an excess of the ketone which leads to the reaction taking other than the desired course. Similar results were found in the case of furfuraldehyde, strong alkali solution at higher temperature gave mostly resinous mass along with a little chalcone.

EXPERIMENTAL

9-Acetylanthracene

It was prepared by the procedure detailed by Hawkins[11] as it was found to be more convenient than that of Gore[12] and after recrystallization from benzene melted at 76°C.

TABLE I

Analytical data of 9-anthryl styryl ketones

	M. P.°C	Formula	Calcd.		Found	
			C	H	C	H
9-anthryl-2-hydroxy-styryl ketone	211	$C_{23}H_{16}O_2$	85·18	4·94	85·56	5·11
9-anthryl-3-hydroxy-styryl ketone	242		85·18	4·94	85·15	5·06
9-anthryl-4-hydroxy-styryl ketone	257		85·18	4·94	85·22	5·01
9-anthryl-2-methoxy-styryl ketone	162	$C_{24}H_{18}O_2$	85·20	5·32	85·44	5·30
9-anthryl-3-methoxy-styryl ketone	128		85·20	5·32	85·06	5·39
9-anthryl-4-methoxy-styryl ketone	105		85·20	5·32	85·01	5·31
9-anthryl-2-chloro styryl ketone	137	$C_{23}H_{15}OCl$	80·46	4·49	80·34	5·01
9-anthryl-3-chloro-styryl ketone	146		80·46	4·49	80·53	5·01
9-anthryl-4-chloro-styryl ketone	174		80·46	4·49	80·48	5·09
9-anthryl-2-nitro-styryl ketone	118	$C_{23}H_{15}O_3N$	78·18	4·25	78·27	4·30
9-anthryl-3-nitro-styryl ketone	182		78·18	4·25	78·00	4·10
9-anthryl-4-nitro-styryl ketone	186		78·18	4·25	78·22	4·39
9-anthryl-2-methyl-styryl ketone	123	$C_{24}H_{18}O$	89·44	5·59	89·55	6·05
9-anthryl-4-methyl-styryl ketone	118		89·44	5·59	89·32	6·00
9-anthryl 2:3 dimethoxy styryl ketone	204	$C_{25}H_{20}O_3$	81·52	5·43	81·35	5·52
9-anthryl 3:4 dimethoxy styryl ketone	162		81·52	5·43	81·54	5·50
9-anthryl-3-methoxy-4-hydroxy styryl ketone	162	$C_{24}H_{18}O_3$	81·35	5·08	81·47	5·00
9-anthryl-3-methoxy-2-hydroxy styryl ketone	303		81·35	5·08	81·27	5·02
9-anthryl-3-methoxy-4-hydroxy-5-bromo styryl ketone	214	$C_{24}H_{17}O_3Br$	66·51	3·93	66·61	4·01
9-anthryl styryl ketone	199	$C_{23}H_{16}O$	89·61	5·19	89·64	5·20
Alpha-anthroyl-beta-furfuryl ethylene	128	$C_{21}H_{14}O_2$	84·96	4·69	84·78	4·99
9-anthryl-4-dimethyl amino styryl ketone	184	$C_{25}H_{21}ON$	85·47	5·98	85·45	6·03

TABLE II

% yield of 9-anthryl styryl ketones

| Name | Molar ratio of 9-acetyl anthracene aryl aldehydes | | | |
| | Cold | | Hot | |
	1:1	1:1·2	1:1	1:1·2
9-anthryl-2-hydroxy-styryl ketone	73·2	76·5	64·9	76·5
9-anthryl-3-hydroxy-styryl ketone	85	76·8	61·2	81
9-anthryl-4-hydroxy-styryl ketone	83	88·6	69	87
9-anthryl-2-methoxy-styryl ketone	83·7	88·3	72	84·4
9-anthryl-3-methoxy-styryl ketone	73·2	78	63·3	77
9-anthryl-4-methoxy-styryl ketone	80	85·4	70·7	84
9-anthryl-2-chloro-styryl ketone	84	88·8	77·2	85·3
9-anthryl-3-chloro-styryl ketone	73·3	83	62·5	81·4
9-anthryl-4-chloro-styryl ketone	82	90	74	85·7
9-anthryl-2-nitro-styryl ketone	76	81	—	—
9-anthryl-3-nitro-styryl ketone	66·3	74·4	—	—
9-anthryl-4-nitro-styryl ketone	76·3	86	—	—
9-anthryl-3-methyl-styryl ketone	87·9	92·8	83·5	89·6
9-anthryl-4-methyl-styryl ketone	87·4	92·7	81·9	89·6
9-anthryl 2:3 dimethoxy styryl ketone	78·85	85	72	82·5
9-anthryl 3:4 dimethoxy styryl ketone	86	84	77·6	86
9-anthryl-3-methoxy-4-hydroxy styryl ketone	66·9	74·5	57·6	75
9-anthryl-3-methoxy-2-hydroxy styryl ketone	80	84	66·6	81
9-anthryl-3-methoxy-4-hydroxy-5-bromo styryl ketone	84·2	88·5	75	85
9-anthryl-4-dimethylamino styryl ketone	81·6	90	69·4	83·7
9-anthryl-styryl ketone	92	93·9	85·5	92
alpha-anthryl-beta-furfuryl ethylene	82·9	29	55·3	—

The general methods employed for the preparation of these compounds were (i) hot condensation (ii) cold condensation taking aldehyde and ketone in equimolar proportion and in the proportion of 1·2:1.

Hot Condensation—In a 125 ml Erlenmeyer flask 0·01 mole of substituted aldehyde and of ketone, in 25 cc ethanol were condensed by adding a strong solution of potassium hydroxide (5 gms in 50 cc water) drop by drop while shaking the ingredients manually. It was then heated in water-bath at about 60°C for four hours. The reaction mixture, after dilution with cold water, was just neutralised with 5% hydrochloric acid, to precipitate the crude chalcone which was filtered, washed with water, dissolved in ether 300 cc and extracted twice with aqueous sodium bicarbonate solution (50 cc, 50 cc), to remove the acid corresponding to the substituted benzaldehyde taken. The ether layer was dried with anhydrous sodium sulphate and the product was purified by several recrystallizations from ethyl acetate. The sodium bicarbonate solution on neutralization gave the corresponding acid. Similar reactions were carried out taking the ketone and substituted benzaldehyde in 1:1·2 ratio.

Cold Condensation—Reaction with stoichiometric proportions were carried out by keeping the reaction mixture at 0°C for half an hour and finally at room temperature for 36 hours, (38°C max.) (see tables) as well as with 20 percent of aldelyde in excess.

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A NOTE ON THE CORRELATION OF FERRIC OXIDE WITH SESQUI-OXIDE CONTENTS OF SOME UTTAR PRADESH SOILS

By

S. K. DE

Chemical Laboratories, University of Allahabad, Allahabad

ABSTRACT

A study was made on the correlation between sesquioxide and ferric oxide contents of sixty four samples of Uttar Pradesh soils and the values reported statistically. A high positive correlation was found to exist between the two values. Regression equations for the two quantities have also been reported. Soil pH and texture had no correlation with either of the values.

Soil sesquioxide is primarily a mixture of aluminium, iron and titanium oxides and is a potent factor determining the availability of phosphate ions of the soil at different levels of pH. The activity of iron and aluminium in relation to phosphate fixation is greatly enhanced as the soil pH moves towards the acidic side. If the soil reaction is not much acidic, this process of fixation is in one sense helpful in that it reduces the so-called 'aluminium toxicity' of the soil but is harmful in another sense because the extent of the availability of iron is also lowered. Iron being well-known for its high electron 'fugacity', its low availability would adversely affect the different redox processes that take place both in soil and plant. It is an established fact that pH of the soil solution which results from complex soil processes diverts almost entirely the movements of the different cations and anions through different soil horizons. It may be a matter of interest to state in this connection that in a number of cases correlations both positive and negative have been observed between two soil constituents clearly indicating their strong tendency to maintain a certain relationship between themselves inspite of polymorphic impacts of the soil environment. Such studies are important from the agriculturo-analysts' point of view because for the matter of prediction of one quantity with respect to the other an insight is obtained as to how one constituent is going to be affected with a change in the other with which it is correlated although it should be clearly remembered that the variables may not necessarily be mutually dependent. For a particular soil group, therefore whenever a correlation is observed between certain of its constituents, there is every reason to believe that the impact of the environment occurred in such a fashion that a close relationship of the constituents became possible.

This conception has been kept in the background in the present correlation study of iron with sesquioxide contents of a number of Uttar Pradesh alluvial soils of different pH and texture, the results of which have been reported in this paper.

EXPERIMENTAL

The soil samples were collected from different parts of Uttar Pradesh from a depth of $0''$ to $6''$.

In the laboratory, the soil samples were properly mixed and dried in air (average temperature 32°C) in diffused sunlight for twelve days. All loose organic matter were removed before the air-dried soil aggregates were broken and pulverised in an agate mortar and passed through a 100-mesh sieve. The pulverised and sieved samples were later stocked in clean and dried bottles for the experiments.

TABLE 1

Ferric and Sesquioxide Contents of some Plain Soils of Uttar Pradesh

Soil No.		pH	Texture	Ferric Oxide (p. c.)	Sesquioxide (p. c.)
Ad	4	10·1	Sandy loam	3·52	7·24
	6	9·3	,,	4·23	7·21
	1	6·7	,,	4·01	8·24
	2	8·4	,,	4·52	14·32
	3	6·7	,,	3·00	6·99
	4	6·5	,,	3·02	8·10
	6	8·1	,,	3·80	8·21
	8	9·4	,,	3·90	9·18
	9	8·3	Silty loam	5·10	15·68
Bs	1	6·8	Sandy loam	3·14	9·02
	2	7·7	,,	3·00	8·20
	3	6·6	Loam	5·61	14·80
	4	7·3	,,	3·12	8·47
	6	7·5	,,	3·14	8·43
	7	7·9	Sandy loam	2·42	5·48
	8	7·8	,,	3·23	6·73
	10	8·2	,,	1·98	6·16
	11	8·1	,,	2·99	7·23
	12	7·6	,,	4·22	15·66
	14	6·7	Loam	1·98	9·64
	15	7·4	Sandy loam	3·23	10·94
By	2	7·4	,,	2·46	5·72
	6	7·3	,,	3·40	6·97
Ji	2	6·6	Loam	1·84	5·80
	3	8·8	,,	1·98	6·63
	4	8·2	Clay loam	6·98	19·01
	6	6 8	Loam	3·10	10·27
	8	7·2	Clay loam	4·10	13·20

TABLE 1 (concld)

Kr 1	7·3	Loam	3·14	6·19
2	6·2	,,	2·98	8·28
3	6·3	,,	3·99	11·20
4	7·3	,,	2·98	8·40
5	6·5	,,	3·43	6·79
6	7·8	Sandy loam	3·98	9·38
7	7·3	Loam	4·13	10·97
8	6·9	,,	5·12	13·18
9	8·3	,,	4·10	8·49
10	8·4	,,	4·00	8·51
11	7·3	,,	2·19	6·38
12	8·0	,,	2·99	6·21
14	6·6	,,	3·24	9·29
15	7·4	,,	4·12	9·45
16	7·3	Silty loam	3·98	9·27
17	7·5	Sandy loam	4·32	9·34
18	7·6	Silty loam	4·31	10·64
19	7·3	,,	4·22	8·31
20	7·1	Sandy loam	5·12	12·10
21	7·8	,,	4·11	9·19
22	7·1	,,	3·99	8·32
23	7·4	Silty loam	3·98	9·92
24	7·3	Sandy loam	3·23	10·45
25	7·3	,,	5·12	9·22
26	7·1	,,	3·32	5·75
27	6·7	Loam	3·42	8·52
28	8·1	Sandy loam	3·44	9 28
29	6·8	,,	4·12	6·63
30	6·3	,,	3·98	7·47
31	7·3	Loam	2·99	7·28
32	7·1	Silty loam	4·12	7·36
33	7·4	,,	3·41	8·48
34	7·3	Silt	4·82	10·71
35	7·4	Loam	4·42	8·51
36	6·4	Silt	3·12	6·22
37	7·2	Loam	4·38	10·32

Note. Ad = Allahabad ; Ah = Aligarh ; Bs = Banaras ; By = Bareilly ; Ji = Jhansi ; Kr = Kanpur.

Soil sesquioxide[1] and ferric oxide[2] were determined by the usual methods. pH was determined electrometrically by Leeds Northrup pH meter and texture by the approximate 'feel and touch' method.

RESULTS AND DISCUSSION

In the given table, it may be observed that the values of ferric oxide or sesquioxide do not bear well-defined relationship between the soil texture and pH. This is quite natural because of different parent materials from which they are originated and complicated effects of climatic factors upon the process of weathering of the latter. Hydrated titanium and aluminium oxides especially ferric oxide[3,4] exist in the soil system mostly as coatings of its mechanical units although their sources of origin in the same system are their primary mineral forms like orthoclase, anorthite, muscovite, magnetite, tourmaline, rutile and ilmenite. In a general way, it may be stated that while sandy and highly weathered residual soils are low in aluminium and ferric oxides, the former class of soils contains titanim to an appreciable amount[5]. This appears to indicate that the loss of one constituent of the soil sesquioxide results in an increase in the quantities of other members. Thus the ultimate quantities of the constituents of sesquioxide do not depend on a single factor.

However, it has been generally observed that the movements of iron through different soil horizons are closely associated with the dynamics of other units of sesquioxides. The primary reasons for this kind of behaviour is yet to be investigated. In our study of correlation of iron with sesquioxide of different plain soils of Uttar Pradesh, we have observed that the two units are positively correlated. The coefficients of correlation and alienation are $(8 \cdot 088 \times 10^{-1})$ $\pm \cdot 0291$ and $5 \cdot 888 \times 10^{-1}$ respectively. The coefficient of forecasting efficiency obtained for the correlation is $41 \cdot 7$ p c. The value of Fischer's t calculated for the observed correlation is $10 \cdot 8251$, the said coefficient of correlation is thus statistically significant. The regression equations obtained for the two values are as follows:—

$$Y \, g^{-100} = - (4 \cdot 858 \times 10^{-1}) + (25 \cdot 946 \times 10^{-1}) \, Y \, g^{-190} \qquad \text{(i)}$$

$$Y \, g^{-100} = (16 \cdot 697 \times 10^{-1}) + (2 \cdot 217 \times 10^{-1}) \, X \, g^{-100} \qquad \text{(ii)}$$

For the two values X and Y, the regression coefficients $(r \, \frac{\sigma x}{\sigma y} \text{ or } r \, \frac{\sigma y}{\sigma x}$; σ = standard deviation) are thus $25 \cdot 946 \times 10^{-1}$ and $2 \cdot 217 \times 10^{-1}$ respectively. In other words, the regression coefficients of X is ten times greater than Y. The most probable value of Y for any given value of X and vice versa can now be regressed by the expressions

$$(\overline{Y} - \check{Y}) = 2 \cdot 17 \times 10^{-1} \, (X - \overline{X}) \qquad [\overline{X} = 90 \cdot 545 \times 10^{-1}] \qquad \text{(iii)}$$

$$(X - \overline{X}) = 25 \cdot 945 \times 10^{-1} \, (Y - \overline{Y}) \qquad [\overline{Y} = 36 \cdot 770 \times 10^{-1}] \qquad \text{(iv)}$$

where $\overline{X}$ and $\overline{Y}$ are equal to $\Sigma \, X/64$ and $\Sigma \, Y/64$ respectively. The values $r \, \frac{\sigma x}{\sigma y}$ and $r \, \frac{\sigma y}{\sigma x}$ are actually the tangents of the angles that the lines (iii) and (iv) will make

with the axis of X. The regression coefficients are thus proper representations for indicating the exent of increase in Y for unit increase of X and vice versa. It may therefore be stated that the value $r \frac{\sigma x}{\sigma y} = 25 \cdot 946 \times 10^{-1}$ signifies that for every change of a unit of the independent variable Y, there is a corresponding variation of $25 \cdot 946 \times 10^{-1}$ of the dependent variable, X. Similarly, for unit increase of X, the independent variable, there is a corresponding change of $2 \cdot 217 \times 10^{-1}$ in Y, the dependent variable as is evident in the expression, $r \frac{\sigma y}{\sigma x} = 2 \cdot 217 \times 10^{-1}$.

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SOME THEOREMS ON HANKEL TRANSFORM

By

G. K. GOYAL

Department of Mathematics, University of Rajasthan, Jaipur

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ABSTRACT

In this note, two theorems on Hankel Transform are proved and some integral representations for the Confluent hypergeometric functions $1F_1$, $2F_2$ and Legendre's function have been obtained by their application.

1. Introduction. The object of this note is to establish certain properties of the Hankel transform and to obtain a few integral representations for the Confluent hypergeometric functions and Legendre's functions by their application.

The Hankel transform of order n of a function $f \in L(0, \infty)$ is defined by the integral equation

$$H_n \left\{ f; p \right\} = \int_0^\infty (pt)^{\frac{1}{2}} J_n (pt) f(t) \, dt, \tag{1.1}$$

where $p > 0$.

2. Theorem 1. If f and $H_n \{f; p\} \in L(0, \infty)$

$$R \left(\frac{\nu}{2} - \frac{1}{4} \right) > R(\mu) > -1 \text{ and } p > 0, \text{ then}$$

$$2^{\nu - \mu - 1} p^{-\mu - \frac{1}{2}} \Gamma(\nu - \mu) H_\mu \left\{ t^{\mu - \nu} f(t); p \right\}$$

$$= \int_0^\infty t^{2\nu - 2\mu - 1} (p^2 + t^2)^{-\nu/2 - \frac{1}{4}} H_\nu \left\{ f; \sqrt{p^2 + t^2} \right\} dt, \tag{2.1}$$

Proof:—From (2.1) it follows that

$$\int_0^\infty H_\nu \left\{ f; \sqrt{u^2 + p^2} \right\} u^{2\nu - 2\mu - 1} (p^2 + u^2)^{-\nu/2 - \frac{1}{4}} du$$

$$= \int_0^\infty u^{2\nu - 2\mu - 1} (p^2 + u^2)^{-\nu/2 - \frac{1}{4}} \left\{ \int_0^\infty t^{\frac{1}{2}} (u^2 + p^2)^{\frac{1}{4}} J_\nu (t \sqrt{u^2 + p^2}) f(t) \, dt \right\} du$$

$$= \int_0^\infty t^{\frac{1}{2}} f(t) \, dt \int_0^\infty u^{2\nu - 2\mu - 1} (p^2 + u^2)^{-\nu/2} J_\nu (t \sqrt{u^2 + p^2}) \, du.$$

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on evaluating the u-integral by the formula (1, p. 343)

$$J_{\nu-\mu-1}(2ap) = \frac{2\,a^{\mu+1}\,p^{\nu-\mu-1}}{1\,(1+\mu)} \int_0^\infty (u^2+p^2)^{-\nu/2}$$

$$J_\nu(2a\sqrt{u^2+p^2})\,u^{2\mu+1}\,du, \qquad (2\cdot2)$$

where $R(\nu/2-\tfrac{1}{4}) > R(\mu) > -1$, we arrive at the result.

The interchange of the order of integration is justified under the conditions stated with the theorem.

Example 1. Let $f(t) = t^{\nu+\frac{1}{2}}\,e^{-a^2t^2/4}\,D_{2n}(at)$

then (2, p. 79),

$$H_\nu \left\{ f(t)\,;\,p \right\} = \frac{2^n\,\Gamma(\nu+3/2)\,p^{\nu+\frac{1}{2}}}{a^{2\nu+2}\,\Gamma(\nu-n+3/2)}\,{}_1F_1\left(\nu+\frac{3}{2}\,;\,\nu-n+\frac{3}{2}\,;\,-\frac{p^2}{2a^2}\right)$$

where

$$|\arg a| < \pi/4,\ R(\nu) > -1 \text{ and } p > 0.$$

Applying (2·1), we find that

$$\frac{\Gamma(\nu-\mu)\,\Gamma(\mu+3/2)\,\Gamma(\nu-n+3/2)}{2\,\Gamma(\mu-n+3/2)\,\Gamma(\nu+3/2)}\,{}_1F_1\left(\mu+\frac{3}{2}\,;\,\mu-n+\frac{3}{2}\,;\,-p^2\right)$$

$$= \int_0^\infty t^{2\nu-2\mu-1}\,{}_1F_1\left\{\nu+\frac{3}{2}\,;\,\nu-n+\frac{3}{2}\,;\,-(p^2+t^2)\right\}\,dt, \qquad (2\cdot3)$$

where $R(\nu-\mu) > 0,\ \mu > -3/2$ and $R(p) > 0$.

Example 2. Let $f(t) = t^{\nu+\frac{1}{2}}\,K_m(\alpha t)\,K_m(\beta t)$

then (2, p. 67),

$$H_\nu \left\{ f(t)\,;\,p \right\} = \frac{\pi^{\frac{1}{2}}\,p^{\nu+\frac{1}{2}}\,\Gamma(\nu+m+1)\,\Gamma(\nu-m+1)}{2^{3/2}\,(\alpha\beta)^{\nu+1}\,(u^2-1)^{\nu/2+\frac{1}{4}}}\,P_{m-\frac{1}{2}}^{-\nu-\frac{1}{2}}(u)$$

where

$$2u\alpha\beta = p^2+\alpha^2+\beta^2,\ R(\alpha) > 0,\ R(\beta) > 0,$$

$$R(\nu) > -1,\ R(\nu\pm m) > -1 \text{ and } p > 0.$$

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Applying (2·1), we find that

$$\frac{2^{\nu-\mu-1}}{\Gamma(\nu+m+1)}\,\Gamma(\nu-\mu)\,\frac{\Gamma(\mu+m+1)\,\Gamma(\mu-m+1)}{\Gamma(\nu-m+1)}\,(\alpha\beta)^{\nu-\mu}\,P_{m-\frac{1}{2}}^{-\mu-\frac{1}{2}}(u)$$

$$=\int_{0}^{\infty}t^{2\nu-2\mu-1}\,(V^2-1)^{-\nu/2-\frac{1}{4}}\,P_{m-\frac{1}{2}}^{-\nu-\frac{1}{2}}(V)\,dt,\qquad (2\cdot4)$$

where $2\alpha\beta V = p^2+t^2+\alpha^2+\beta^2$, $R(\nu-\mu)>0$,

$R(\alpha)>0$, $R(\beta)>0$, $R(p)>0$, $R(\nu-2\mu+2m-3/2)<0$

and $R(\nu-2\mu+2m-\frac{1}{2})<0$.

3. *Theorem 2.* If f and $H_n\{f;p\} \in L(0,\infty)$

$R(m-n)>0$, $R(p)>0$ and $R(n+1)>0$.

then

$$\left(\frac{2}{p}\right)^{m-n}\Gamma(m-n)\,H_m\left\{t^{m-n}\,f(t);p\right\}$$

$$=\int_{0}^{\infty}t^{m-n-1}\,(1+t)^{n/2-m-\frac{3}{4}}\,H_n\left\{f;\frac{p}{\sqrt{1+t}}\right\}dt,\qquad (3\cdot1)$$

The proof is similar to that of theorem 1 if we use the integral (3, p. 334)

$$J_m(a\lambda)=\frac{1}{\Gamma(m-n)}\left(\frac{a\lambda}{2}\right)^{m-n}\int_{0}^{\infty}u^{m-n-1}\,(1+u)^{n/2-m-1}$$

$$J_n\left(\frac{a\lambda}{\sqrt{1+u}}\right)du,\qquad (3\cdot2)$$

where $R(m-n)>0$, $R(n+1)>0$.

instead of (2·2).

Example 3. Let $f(t)=t^{\mu-\frac{1}{2}}e^{-at^2}$

then (2, p. 30),

$$H_n\left\{f(t);p\right\}=\frac{p^{n+\frac{1}{2}}\,\Gamma\left(\frac{(n+\mu+1)}{2}\right)}{2^{n+1}\,a^{\frac{1}{2}(\mu+n+1)}\,\Gamma(1+n)}\,{}_1F_1\left(\frac{\mu+n+1}{2};n+1;-\frac{p^2}{4a}\right)$$

where $R(a)>0$, $R(\mu+n)>-1$

[461]

Applying (3·1), we find that

$$\frac{\Gamma\ (m-n)\ \Gamma\ (n+1)}{\Gamma\ (m+1)}\ {}_1F_1\left(\frac{\mu+n+1}{2}\ ;m+1\ ;\ -p\ \right)$$

$$\int_0^\infty u^{m-n-1}\ (1+u)^{-m-1}\ {}_1F_1\left(\frac{\mu+n+1}{2};n+1;\ -\ \frac{p}{1+u}\ \right)du, \qquad (3\cdot3)$$

where R $(m-n) > 0$, R $(1+n-\mu) > 0$ and R $(p) > 0$.

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CROSS-RADIAL OSCILLATIONS OF MAGNETIC STARS

By

A. C. BANERJI* and V. K. GURTU

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ABSTRACT

In the present paper we have considered the possibility of cross-radial oscillations of a spherical magnetic star of radius R. Three cases have been discussed. In the first case density is taken to vary inversely as an integral multiple of radius vector, except in a small finite sold core of radius ϵ. It has been shown that the cross-radial oscillations are possible at certain latitudes θ_0 (which depend upon n, the order of spherical harmonies). The most remarkable point is that the latitudes at which the oscillations are possible are symmetrical with respect to $\theta_0 = \pi/2$ and have the same frequency on either side. For certain values of n, uniform oscillation are also possible. Also when n is odd, the oscillations are possible at $\theta_0 = \pi/2$ and the value of the frequency at it is minimum when compared with the other values of the frequencies. In the second case density is taken to be uniform. The results obtained are more or less same as in the first case except that there is no possibility of uniform oscillations for any value of n.

In the third case we have taken density depending upon the latitude θ_0 i.e. $\rho = \dfrac{\alpha(1 + \cos^2 \theta)}{r^m}$. It has been shown that when n is even and $m\,\gamma > 2n + 4$ oscillations are possible at $\theta_0 = \pi/2$ in a region between the surface of the solid core and a sphere of radius $R_1 < R$ where R_1 depends upon n. When n is odd, the oscillations are possible in the whole star at $\vartheta_0 = \pi/2$ for every $m\gamma$.

INTRODUCTION

In the earlier communication[1] we considered the stability of radial oscillations of a more or less spherical magnetic star. In the present case we shall be investigating the possibility of cross-radial oscillations. Though a spherical symmetry of configuration is, in general, incompatible with the presence of the fluid motions and magnetic fields, bur there is also an exception.[2] It has been found by Chandrasekhar that for stability the ration of the specific heats γ must be greater than $4/3$ and that the total magnetic energy of a system should not exceed its negative gravitational potential energy. This would require that magnetic field should be sufficiently small.

In the present case we shall derive the magnetic field from a potential of the form S_n/r^{n+1} where S_n is the surface harmonies of degree n. It may be mentioned here that the material present in the gaseous star is assumed to be non-magnetic and the magnetic field arises entirely from magnetism inside the system.

Assuming S_n to be independent of ϕ, we can replace S_n by P_n, the Legendre's coefficient which can be expressed as[3]

$$P_n = a \cos n\,\theta + b \cos (n-2)\,\theta + c \cos (n-4)\,\theta + \qquad \cdots \ (1)$$

$$\left.\begin{array}{l}
\text{where } a = 2.\,\dfrac{1.\ 3.\ 5.\ \cdots\cdots\cdots\ (2n-1)}{2.\ 4.\ 6.\ \cdots\cdots\cdots\ (2n)} \\[3mm]
b = 2.\,\tfrac{1}{2}.\,\dfrac{1.\ 3.\ 5.\ \cdots\cdots\cdots\ (2n-3)}{2.\ 4.\ 6.\ \cdots\cdots\cdots\ (2n-2)} \\[3mm]
c = 2.\,\tfrac{1}{2}.\,\tfrac{3}{4}.\,\dfrac{1.\ 3.\ 5.\ \cdots\cdots\ (2n-5)}{2.\ 4.\ 6.\ \cdots\cdots\ (2n-4)} \text{ etc.}
\end{array}\right\} \qquad \cdots \ (2)$$

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*Present address: 4,A-Beli Road, Allahabad.

Thus the magnetic field can be obtained as

$$H^2 = \frac{l_n^2}{r^{2n+4}} \Big[(n+1)^2 \{a \cos n\,\theta + b \cos (n-2)\theta + c \cos (n-4)\theta + \ldots\}^2$$

$$+ \{a\,n \sin n\,\theta + b(n-2) \sin (n-2)\theta + c(n-4) \sin (n-4)\theta + \ldots\}^2 \Big] \rightarrow (3)$$

Having decided about the magnetic field, we now proceed to formulate equations governing the motion. Assuming (v_r, v_θ, v_ϕ), the three components of the velocity at any point (r, θ, ϕ) at any instant of time 't', to be small quantities of first order the tree equations[4] governing the motion will be

$$\frac{d^2r}{dt^2} = F_r - \frac{1}{\rho}\,\frac{\partial p}{\partial r}$$

$$\frac{r\,d^2\theta}{dt^2} = F_\theta - \frac{1}{\rho r}\,\frac{\partial p}{\partial \theta} \qquad \Bigg\} \quad \ldots \ (4)$$

$$r \sin \theta\,\frac{d^2\phi}{dt^2} = F_\phi - \frac{1}{\rho r \sin \theta}\,\frac{\partial p}{\partial \phi}$$

where p, ρ and (F_r, F_θ, F_ϕ) denote pressure, density and three components of external force F.

F, in general, will consist of gravitational, magnetic and electrical forces.

(i) Gravitational force 'g' will act along radius vector, and so will not contribute in the direction of θ.

(ii) Magnetic force $\overline{F}_m$ will be given by[5]

$$\overline{F}_m = - \text{grad} \left(\frac{\mu H^2}{8\pi} \right) + \text{div} \left(\frac{\mu \overline{H}\,\overline{H}}{4\pi} \right) \qquad \ldots \ (5)$$

which implies that $\overline{F}_m$ is equivalent to a hydrostatic pressure $\frac{\mu H^2}{8\pi}$ and a tension

$\frac{\mu H^2}{4\pi}$. If we assnme our magnetic field to be constant along a line of force but to vary from one line of force to another, then it can be seen that the efiect of the magnetic field will reduce to that of a magnetic pressume $\frac{\mu H^2}{8\pi}$. Then the 'total

pressure' will become $\left(p + \frac{\mu H^2}{8\pi} \right)$.

(iii) As conductivity is assumed to be infinite, the total elecric field on the moving material is zero.

Thus the equations (4) of motion will become

$$\frac{d^2r}{dt^2} = -g - \frac{1}{\rho}\frac{\partial}{\partial r}\left(p + \frac{\mu H^2}{8\pi}\right) \qquad \text{... (6)}$$

$$\frac{d^2\theta}{dt^2} = -\frac{1}{\rho r^2}\frac{\partial}{\partial\theta}\left(p + \frac{\mu H^2}{8\pi}\right) \qquad \text{... (7)}$$

$$\frac{d^2\phi}{dt^2} = -\frac{1}{\rho r^2\sin^2\theta}\frac{\partial}{\partial\phi}\left(p + \frac{\mu H^2}{8\pi}\right) \qquad \text{... (8)}$$

Equation (6) gives the nature of radial motion and has already been dealt with.

In the present paper we assume that the motion is predominently cross-radial and then shall deal with equation (7) for investigating the possibility of cross-radial oscillations.

For adiabatic changes, pressure and density are connected by the relation.

$$p = k\rho^\gamma \qquad \text{... (9)}$$

where γ is the ratio of specific heats.

In view of (3) and (9), equation (7) of cross-radial motion becomes

$$\frac{d^2\theta_1}{dt^2} = -\left[\frac{k\gamma}{r^2\rho^{2-\gamma}}\frac{\partial\rho}{\partial\theta} - \frac{\mu I_n^2}{8\pi\rho r^{2n+6}}\left\{a_1\sin 2n\theta + b_1\sin 2(n-1)\theta\right.\right.$$

$$+ c_1\sin 2(n-2)\theta + a_2\sin 2(n-3)\theta + b_2\sin 2(n-4)\theta + c_2\sin 2\theta + a_3\sin 4\theta + \ldots\}]$$

$$\text{... (10)}$$

where a_1, b_1, c_1, are given by

$a_1 = n(2n+1)a^2$, $\quad b_1 = 2(n-1)(4n+1)ab$,

$c_1 = (n-2)\{3(2n-1)b^2 + 2(6n+1)ac\}$, $a_2 = 2(n-3)(8n-7)bc$

$b_2 = 5(n-4)(2n-3)c^2$, $\qquad\qquad\qquad\qquad$ ... (11)

$c_2 = 2b\{(2n^2+1)a + (2n^2 - 4n + 9)c\}$,

$a_3 = 4ac(2n^2 - 2n + 1)$ etc.

Case 1. Variable density.

We shall now consider the case in which the density is varying inversely as the mth power of the distance from the centre (where m is a positive integer), except in a small but finite solid core of radius ϵ having constant density, surrounding the centre of the star of radius R.

Let $\rho = \alpha/r^m$, where α is a constant.

Thus equation (10) becomes

$$\frac{d^2\theta}{dt^2} = \frac{\mu l_n^2}{8\pi\alpha r^{2n+6-m}} \left\{ a_1 \sin 2n\theta + b_1 \sin 2(n-1)\theta \right.$$

$$\left. + c_1 \sin 2(n-2)\theta + \ldots \right\} \qquad \ldots (12)$$

In order to study cross-radial oscillations we put in (12)

$$\theta = \theta_o + \theta_1 \qquad \ldots (13)$$

where θ_0 is the undisturbed value of θ, and θ_1 is a small quantity of first order so that θ_1^2 etc. are neglected.

Then $\qquad \dfrac{d^2\theta}{dt^2} = \dfrac{d^2\theta_1}{ct^2} \qquad \ldots (14)$

and $\quad \sin M\theta = \sin M\theta_0 + (M \cos M\,\theta_0)\,\theta_1 \qquad \ldots (15)$

on expanding and neglecting θ_1^2 etc.

The constant M will have the values $2n$, $2(n-1)$, $2(n-2)$, $2(n-3)$, $2\,n-4)$, $2,4$, etc.

From (14) and (15) equation (12) will become

$$\frac{d^2\theta_1}{dt^2} = A + B\,\theta_1 \qquad \ldots (16)$$

where

$$A = \frac{\mu l_n^2}{8\pi\alpha r^{2n+6-m}} \left\{ a_1 \sin 2n\theta_0 + \ldots \ldots \right\} \qquad \ldots (17)$$

and

$$B = \frac{\mu l_n^2}{8\pi\alpha r^{2n+6-m}} \left\{ 2na_1 \cos 2n\theta_0 + 2(n-1)\,b_1 \cos 2(n-1)\,\theta_0 \right.$$

$$\left. + \ldots\ldots\ldots\ldots\ldots \right\} \qquad \ldots (18)$$

In general, the equation (16) will have two solutions $viz.$

$$\theta_1 = -A/B + C \cos \sqrt{B}\,t + D \sin \sqrt{B}\,t \Big\}$$

or, $\qquad \theta_1 = -A/B + C\,e^{\sqrt{-B}\,t} + D\,e^{\sqrt{-B}\,t} \Big\} \qquad \ldots (19)$

according as B is positive or negative ; C and D being arbitrary constants.

The ratio A/B is given by

$$\frac{A}{B} = \frac{\{ a_1 \sin 2n\theta_0 + \cdots\cdots \}}{\{ 2na_1 \cos 2n\theta_0 + \cdots\cdots \}} \qquad\qquad \cdots (20)$$

For equations (19) to be consistent, it is necessary that the ratio A/B must at most be a small quantity of the same order as θ_1 it may also be equal to zero. When the ratio A/B is not small equations (19) will not be consistent. For certain values of θ_0 viz. 0, $\pi/2$, π we see that the ratio A/B will be zero ; there may also be other values of θ_0 (depending upon the value of n) which will make the ratio A/B zero. Therefore in such cases when A/B is zero, equations (19) will be reduced to

$$\theta_1 = C \cos \sqrt{B} t + D \sin \sqrt{B} t \qquad\qquad \cdots (21)$$

and

$$\theta_1 = C e^{\sqrt{-B} t} + D e^{-\sqrt{-B} t} \qquad\qquad \cdots (22)$$

It is evident now that equation (21) will represent an oscillatory motion whereas equation (22) will not.

In order to find out the values of the arbitrary constants C and D of equation (21) of oscillatory motion we shall suppose that the particle is oscillating in longitudnal plane ϕ = constant about the radius vector having vectorial angle θ_0, within the region included between the radii vectores having $(\theta_0 + \eta)$ and $(\theta_0 - \eta)$ as their vectorial angles, η being a small quantity at most of the same order as θ_1. Thus we have

(1) at $t = 0$, $\theta_1 = \eta$ (radians)

(2) at $t = 0$. $\dfrac{d\theta_1}{dt} = 0$

Using these conditions we get C = η, D = 0.

Therefore (21) will become

$$\theta_1 = \eta \cos \sqrt{B} t \qquad\qquad \cdots (23)$$

Thus we find that (16) will represent an oscillatory motion if A = O and B is negative. By applying these conditions, we can, for $n = 2, 3, 4, 5$ get the values of θ_0 at which oscillations will be possible.

Following is the table giving the squares of frequencies at different latitudes (θ_0).

Latitudes (θ_0)	Square of Frequency for $n = 2$ (multiple of $\dfrac{\mu l_2^2}{\pi \alpha \,_r{}^{10-m}}$)	Square of Frequency for $n = 3$ (multiple of $\mu l_3^2/\pi \alpha \,_r{}^{12-m}$)	Square of Frequency for $n = 4$ (multiple of $\mu l_4^2/\pi \alpha r^{14-m}$)	Square of Frequency for $n = 5$ (multiple of $\mu l_5^2/\pi \alpha \,_r{}^{16-m}$)	For $n = 6,7$
$\theta_0 = 90° - 56\tfrac{1}{2}°$				13·33	
$\theta_0 = 90° - 50\tfrac{1}{2}°$			6·28		
$\theta_0 = 90° - 42°$		4·42			
$\theta_0 = 90° - 28°$				6·55	
$\theta_0 = 90° - 26\tfrac{1}{2}°$	1·80				
$\theta_0 = 90° - 17°$			4·40		
$\theta_0 = 90°$		2·81		6·15	
$\theta_0 = 90° + 17°$			4·40		
$\theta_0 = 90° + 26\tfrac{1}{2}°$	1·80				
$\theta_0 = 90° + 28°$				6·55	
$\theta_0 = 90° + 42°$		4·42			
$\theta_0 = 90° + 50\tfrac{1}{2}°$			6·28		
$\theta_0 = 90° + 56\tfrac{1}{2}°$				13·33	

From the above table it may be noticed that for particular n and θ_0 the ratio K of the frequency on the surface of the solid core and that on the surface of the star is given by

$$K = (R/\epsilon)^{n+3-m/2}$$

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Evidently for $m < 2n + 6$, K is pretty large, the maximum value being $(R/\epsilon)^{n+6/2}$ when $m = 1$ and the minimum value being $(R/\epsilon)^{\frac{1}{2}}$ when $m = 2n + 5$. We also notice that for a particular value of n, frequency goes on decreasing as r increases from ϵ to R, being maximum on the surface of the solid core and minimum on the surface of the star. Though the ratio K is pretty large in this case, yet the frequency is possible as the common multiple $\sqrt{\mu l_n^2/\pi\alpha}$ is sufficiently small. There will thus be a rapid decrease in the frequency.

For $m = 2n + 6$, K is unity which corresponds to uniform frequency.

For $m > 2n + 6$, K becomes very small, its maximum value being $(\epsilon/R)^{\frac{1}{3}}$ when $m = 2n + 7$. We also notice that for a particular n frequency goes on increasing as r increases from ϵ to R, being minimum on the surface of the solid core and maximum on the surface of the star. Even though K is small yet there will be a rapid increase in the frequency as we go from ϵ to R.

From (12) it is evident that if at all there are oscillations they must be due to the magnetic field H. We have supposed H to be derivable from a potential of the form P_n/r^{n+1}, where P_n, given by (1), is a function of n and θ. Thus for a particular point (r, θ) on the longitudnal plane $\phi = $ constant, n can change and from the table we notice the following facts.

Firstly oscillations are possible at $\theta_0 = \pi/2$ only when n is odd and not when it is even. Secondly for a particular n the value of the frequency is minimum at $\theta_0 = \pi/2$ when compared with frequencies at other latitudes. Thirdly the other latitude at which the oscillations are possible, are symmetrical with respect to $\theta_0 = \pi/2$ and have the same frequency on either side. Fourthly, in no case oscillations are possible at $\theta_0 = 0, \pi$.

Units :—It can be seen from the following calculations that the unit for various frequencies is $1/T$, where T is the unit for time. It may be noted that the unit for the frequency in every case is the unit for the common multiple $\sqrt{\mu l_n^2/\alpha r^{2n+6-m}}$. If M and L are the units for mass and length, then Unit of $H^2 = L^{-1} M T^{-2} \mu^{-1}$ Unit of $r = L$, Unit of $\rho = L^{-3} M$

Therefore unit for $l_n^2 = L^{2n+3} M T^{-2} \mu^{-1}$ from (3), and unit for $\alpha = L^{m-3} M$ from $\rho = \alpha/r^m$.

Therefore the unit for $\sqrt{\mu l_n^2/\alpha r^{2n+6-m}} = 1/T$ (on substitution) which is the unit for frequency.

Case 2. Uniform density ρ.

In this case the equation (10) of cross-radial motion is given by

$$\frac{d^2\theta}{dt^2} = \frac{\mu l_n^2}{8\pi \rho r^{2n+6}} \left\{ a_1 \sin 2n\theta + b_1 \sin 2(n-1)\theta + \ldots\ldots \right\}$$

which can also be obtained from (12) on putting $m = 0$ and $\alpha = \rho$. It can be seen that in this case the results will remain the same as in the previous case except with a few differences. The results are summerised below.

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The ratio $\dot{\text{K}}$ of the frequency on the surface of the solid core and that on the surface of the star remains the same for a particular value of n and is given by

$$K = \left(\frac{R}{\epsilon}\right)^{n+3}$$

Evidently this ratio is pretty large, its minimum value being $(R/\epsilon)^5$ when $n = 2$. Further this ratio K can never be equal to unity *i,e.* in this case uniform frequency is not possible as in the previous case. As the least value of the ratio K is $(R/\epsilon)^5$, it is easy to see that, in general, the frequency of the cross-radial oscillations will be very great.

We can also see that the unit for various frequencies will be $1/T$ as in the previous case.

Case 3 :—We shall now consider the case in which the density ρ satisfies the relation

$$\rho = \alpha (1 + \cos^2\theta)/r^m$$

(where m is a positive integer)

except in a small but finite solid core of radius ϵ having constant density surrounding the centre of the star of radius R.

In this case equation (10) of cross radial motion becomes

$$\frac{d^2\theta}{dt^2} = \left[\frac{k\gamma \, \alpha^{\gamma-1} \sin 2\theta}{(1 + \cos^2\theta)^{2-\gamma} \cdot r^{m(\gamma-1)+2}} + \frac{\mu l_n^2 \, r^{m-2n-6}}{8\pi \, \alpha(1 + \cos^2\theta)} \left\{ a_1 \sin 2n\theta + \right. \right.$$

$$\left. \left. b_1 \sin 2(n-1)\theta + \dots\dots\dots\dots \right\} \right] \qquad \dots \text{(24)}$$

where a_1, b_1, c_1 ... ... etc. are defined by (11)

In order to study the cross-radial oscillations we shall put $\theta = \theta_0 + \theta_1$ in (24) as in the first case to get

$$\frac{d^2\theta_1}{dt^2} = A + B\theta_1 \qquad \dots \text{(25)}$$

where

$$A = \left[\frac{k\gamma \, \alpha^{\gamma-1} \sin 2\theta_0}{(1 + \cos^2\theta_0)^{2-\gamma} \cdot r^{m(\gamma-1)+2}} + \frac{\mu l_n^2 \, r^{m-2n-6}}{8\pi \, \alpha(1 + \cos^2\theta_0)} \left\{ a_1 \sin 2n\theta_0 \right. \right.$$

$$\left. \left. + b_1 \sin 2(n-1)\theta_0 + \dots\dots\dots\dots \right\} \right] \qquad \dots \text{(26)}$$

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and

$$B = \frac{k\gamma\,\alpha^{\gamma-1}}{(1+\cos^2\theta_0)^{2-\gamma}\,r^{m(\gamma-1)+2}}\left\{2\cos 2\theta_0 + \frac{(2-\gamma)\sin^2 2\theta_0}{1+\cos^2\theta_0}\right\}$$

$$+ \frac{\mu l_n^2\,r^{m-2n-6}}{8\pi\alpha\,(1+\cos^2\theta_0)}\left[\frac{\sin 2\theta_0}{1+\cos^2\theta_0}\,(a_1\sin 2n\theta_0 + \ldots) + (2na_1\cos 2n\theta_0 + \ldots)\right]$$
$$\ldots \quad (27)$$

It is clear from equation (25) that for cross-radial oscillations A should be zero and B should be negative. We shall discuss the cases when $n = 2, 3, 4, 5$. It is clear from (26) that $A = 0$ when $\theta_0 = 0, \pi/2, \pi$. But it may be seen that B will be negative only at $\theta_0 = \pi/2$ i.e. the oscillations will be possible at $\theta_0 = \pi/2$ only.

(i) For $n = 2$, the equation of motion at $\theta_0 = \pi/2$ is

$$\frac{d^2\theta_1}{dt} = - \frac{1}{r^{m(\gamma-1)+2}}\left[2k\gamma\,\alpha^{\gamma-1}\frac{9\mu l_2^2}{-8\pi\alpha\,r^{8-m\gamma}}\right]\theta_1 \quad \ldots \quad (28)$$

which will represent an oscillatory motion if the quantity within brackett is positive, that is, when $r = r_2$ is such that

$$r_2 > \left[\frac{9\,\mu l_2^2}{16\pi k\gamma\,\alpha^\gamma}\right]^{\frac{1}{8-m\gamma}} \geq \epsilon \quad \ldots \quad (29)$$

from which we may choose l_2 such that

$$l_2 > \left[\frac{16\,\pi k\gamma\,\alpha^\gamma}{9\,\mu\epsilon^{m\gamma-8}}\right]^{1/2} \quad \ldots \quad (30)$$

which will hold good if $m\gamma > 8$, for ϵ is finite and l_2 is sufficiently small.

(ii) For $n = 3$ the equation of motion at $\theta_0 = \pi/2$ is

$$\frac{d^2\theta_1}{dt^2} = - \frac{1}{r^{m(\gamma-1)+2}}\left\{2k\gamma\,\alpha^{\gamma-1} + \frac{45\,\mu l_3^2}{16\,\pi\alpha\,r^{10-m\gamma}}\right\}\theta_1 \quad \ldots \quad (31)$$

which represents an oscillatory motion for every $m\gamma$ without any lower limit for l_3.

(iii) For $n = 4$ the equation of motion at $\theta_0 = \pi/2$ is

$$\frac{d^2\theta_1}{dt^2} = - \frac{1}{r^{m(\gamma-1)+2}}\left\{2k\gamma\,\alpha^{\gamma-1} - \frac{225\,\mu l_4^2}{64\,\pi\alpha r^{12-m\gamma}}\right\}\theta_1 \quad \ldots \quad (32)$$

which will represent an oscillatory motion if the quantity within brackett is positive, that is, when $r = r_4$ is such that

$$r_4 > \left[\frac{225\ \mu l_4{}^2}{123\ \pi k \gamma \alpha^{\gamma}} \right]^{\frac{1}{12 - m\gamma}} \geqslant \epsilon \qquad \cdots (33)$$

from which we may choose l_4 such that

$$l_4 \geqslant \left[\frac{128\ \pi k \gamma \alpha^{\gamma}}{225\ \mu \epsilon^{m\gamma - 12}} \right]^{1/2} \qquad \cdots (34)$$

which will hold good if $m\gamma > 12$.

(iv) For $n = 5$, the equation of motion at $\theta_0 = \pi/2$ is

$$\frac{d^2\theta_1}{dt^2} = - \frac{1}{r^{m(\gamma - 1) + 2}} \left\{ 2k\gamma \alpha^{\gamma - 1} + \frac{1575\ \mu l_5{}^2}{256\ \pi \alpha\ r^{14 - m\gamma}} \right\} \theta_1 \qquad \cdots (35)$$

which represents an oscillatory motion for every $m\gamma$ without any lower limit for l_5.

From the cases $n = 2$, 4 it appears that when n is even and $m\gamma > 2n + 4$, oscillations are possible at $\theta_0 = \pi/2$ in the region included between the surface of solid core and a sphere of radius R_1 (depends upon n).

From the cases $n = 3$, 5 it appears that when n is odd, oscillations are possible only at $\theta_0 = \pi/2$ in the whole star excluding, of course, the solid core.

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CROSS-RADIAL MOTION INSIDE A VISCOUS MAGNETIC STAR

By

A. C. BANERJI* *and* V. K. GURTU†

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ABSTRACT

The motion inside a magnetic star is considered in the case when the velocity component along the θ-direction predominates over other velocity components. It has been assumed that the magnetic field arises from a scalar potential of the form P_n/r^{n+1} where P_n denotes the Legendre's coefficient. Viscous force has also been taken into account. Two laws of density have been assumed. It has been shown that even if the velocity at any other point is not large, the motion, in general, will be turbulent at the latitudes $\theta = 0, \pi$. But by fixing rigid boundaries at $\theta = \delta, \pi - \pi, \delta$ being small, the turbulence could be avoided. Then the motion will be such that on every longitudnal planes fluid will have a tendency of flowing along different arcs of circle towards the latitude $\theta = \pi/2$. In case the density also depends upon θ it has been seen that cross-radial velocity is comparatively larger than in the case when density does not depend upon θ. It has also been pointed out that the atitudes of maximum (numerically) velocity will shift towards $\theta = \delta, \pi - \delta$ as n increases.

INTRODUCTION

In an earlier communication[1] we considered radial motion inside a viscous magnetic star and showed that the star had a tendency to contract or expand radially depending upon the law of density assumed. In the present paper we shall consider the cross-radial motion along circles of different radii on longitudnal planes of such a magnetic star. Our aim is to find out the nature of motion inside the magnetic star in general, *i. e.* whether there is turbulence or circulatory motion. Several authors have already discussed the nature of large scale motions in the solar photospheres, though there is yet a controversy over it. For example, Plaskett[2] believes that there is a hierarchy of turbulent motions. Others such as Bjerknes[3] believe that there is circulation. In a very recent paper, M. A. Klyakotka and N. I. Kozhevnikov[4] have shown that in the Solar Photosphere the motion is predominantly circulatory.

Let (q_r, q_θ, q_ϕ) denote the three components of velocity in the direction of $dr, rd\theta, r \sin \theta d\phi$, (r, θ, ϕ) being the spherical polar coordinates of the point at a certain instant of time t. Here we will neglect q_r and q_ϕ in comparison with q_θ. We shall also neglect the square of q_θ and its variation with r and ϕ so that q_θ can be taken to denote the cross-radial velocity. Henceforth we will drop the suffix θ and write q for q_θ. Here we shall be examining if there is a possibility of turbulent motion for some cause or the other *e. g.* due to magnetic force. If there be any turbulent motion at a point we will take $\theta = 0$ as the line joining that point to the centre of the star.

*4 A-Beli Road, Allahabad-2
†Department of Mathematics, University of Allahabad, Allahabad.

Thus the equation[5] of cross-radial motion in the Hydrodynamical steady state can be written as

$$o = F_\theta - \frac{1}{\rho r}\frac{\partial p}{\partial \theta} + \frac{\beta}{\rho}\left(\frac{\cot\theta}{r^2}\frac{dq}{d\theta} + \frac{1}{r^2}\frac{\partial^2 q}{\partial\theta^2} - \frac{q}{r^2\sin^2\theta}\right) \tag{1}$$

where F_θ, p, ρ and β denote the cross-radial component of external force F, pressure, density and coefficient of viscosity (which remains constant for gases). External force F, in general, will consists of gravitational, magnetic and electrical forces.

Since the star is assumed to be more or less spherical there will be no component of gravitational force along θ-direction.

The effect of magnetic force $\overline{H}$ is just to increase the pressure by $\frac{\mu H^2}{8\pi}$, if the magnetic field is supposed to be constant along a line of force but to vary from one line of force to another[6]. Thus the total pressure will become $p + \frac{\mu H^2}{8\pi}$; μ is magnetic permeability.

The electrical force will be zero as the conductivity assumed is infinite.

Therefore (1), after simplification, gives

$$\frac{d^2 q}{d\theta^2} + \cot\theta\ \frac{dq}{d\theta} - \mathrm{cosec}^2\theta\cdot q = \frac{r}{\beta}\frac{\partial}{\partial\theta}\left(p + \frac{\mu H^2}{8\pi}\right) \tag{2}$$

We take adiabatic relation between p and ρ viz

$$p = k\rho^\gamma \tag{3}$$

where γ is the ratio of specific heats.

For finding out an expression for H, we assume that the magnetic field arises entirely from magnetism inside in the star. In this case the potential of the magnetic system must satisfy the Laplace's equation and hence we assume, as a simple case, that H is deviabable from a potential of the form S_n/r^{n+1}, where S_n is the surface harmonics of degree n. We take S_n to be independent of ϕ and therefore replace it by P_n, the Legendre's coefficient, which can be expressed as

$$P_n = a\cos n\theta + b\cos(n-2)\theta + c\cos(n-4)\theta + \tag{4}$$

$$\text{where } a = 2.\ \frac{1.\,3.\,5\,\ldots\ldots(2n-1)}{2.\,4.\,6\,\ldots\ldots(2n)}$$

$$b = 2.\tfrac{1}{2}\ \frac{1.\,3.\,5\ldots\ldots(2n-3)}{2.\,4.\,6\ldots\ldots(2n-2)}$$

$$o = 2.\tfrac{1}{2}.\tfrac{3}{4}.\ \frac{1.\,3.\,5\ldots\ldots(2n-5)}{2.\,4.\,6\ldots\ldots(2n-4)}\ \text{etc.} \tag{5}$$

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Thus, H will be given by

$$H = \frac{l_n}{r^{n+2}} \left[(n+1)^2 P_n^2 + \left(\frac{\partial P_n}{\partial \theta} \right)^2 \right] \tag{6}$$

where l_n is a small constant introduced to ensure that H is taken to be sufficiently small.

From (2), (3), (4) and (6) we have

$$\frac{d^2q}{d\theta^2} + \cot \theta \frac{dq}{d\theta} - q \csc^2 \theta = \left[\frac{rk\gamma}{\beta} \rho^{\gamma-1} \left(\frac{\partial \rho}{\partial \theta} \right) \right.$$

$$- \frac{\mu l_n^2}{8\pi\beta} \frac{1}{r^{2n+3}} \left\{ a_1 \sin 2n\,\theta + b_1 \sin 2(n-1)\,\theta + c_1 \sin 2(n-2)\,\theta \right.$$

$$+ a_2 \sin 2(n-3)\,\theta + b_2 \sin 2(n-4)\,\theta + c_2 \sin 2\theta$$

$$\left. \left. + a_3 \sin 4\theta + \cdots \right\} \right] \tag{7}$$

where
$$\begin{aligned}
a_1 &= n\,(2n+1)\,a^2, \quad b_1 = 2\,(n-1)\,(4n+1)\,ab \\
c_1 &= (n-2)\,\{3\,(2n-1)\,b^2 + 2\,(6n+1)\,ac\} \\
a_2 &= 2\,(n-3)\,(8n-7)\,bc, \quad b_2 = 5\,(n-4)\,(2n-3)\,c^2 \\
c_2 &= 2\,b\,\{(2n^2+1)\,a + (2n^2-4n+9)\,c\,\} \\
a_3 &= 4ac\,(2n^2-2n+1) \text{ etc.}
\end{aligned} \right\} \tag{8}$$

Case 1 :—We now consider a model in which the density varies inversely as an integral power, say m, of the distance from the centre, except in a small but finite solid core of constant density. Thus let

$$\rho = \alpha/r^m \tag{9}$$

where α is a constant.

It may be mentioned here that this law also includes the case of uniform density when $m = 0$ and the radius of the solid core tends to zero.

In view of (9), we can write (7) as

$$\frac{d^2q}{d\theta^2} + \cot\theta \cdot \frac{dq}{d\theta} - q \csc^2\theta = - \frac{\mu l_n^2}{8\pi\beta \, r^{2n+3}} \left\{ a_1 \sin 2n\theta + \cdots \right\} \tag{10}$$

[475]

The solution of (10) can be obtained as

$$q = \frac{1}{\sin\theta}\left[2C \sin^2{\tfrac{1}{2}\theta} + \right.$$

$$2D \cos^2{\tfrac{1}{2}\theta} - \frac{\mu l_n^2}{16\pi\beta\, r^{2n+3}}\left\{ \frac{a_1}{n}\left(\frac{\cos(2n+1)\theta}{2n+1} - \frac{\cos(2n-1)\theta}{2n-1} \right) \right.$$

$$+ \frac{b_1}{2(n-1)}\left(\frac{\cos(2n-1)\theta}{2n-1} - \frac{\cos(2n-3)\theta}{2n-3} \right)$$

$$+ \frac{c_1}{2(n-2)}\left(\frac{\cos(2n-3)\theta}{2n-3} - \frac{\cos(2n-5)\theta}{2n-5} \right)$$

$$+ \frac{a_2}{2(n-3)}\left(\frac{\cos(2n-5)\theta}{2n-5} - \frac{\cos(2n-7)\theta}{2n-7} \right)$$

$$+ \frac{b_2}{2(n-4)}\left(\frac{\cos(2n-7)\theta}{2n-7} - \frac{\cos(2n-9)\theta}{2n-9} \right)$$

$$+ \frac{c_2}{2}\left(\frac{\cos 3\theta}{3} - \frac{\cos\theta}{1} \right)$$

$$\left. \left. + \frac{a_3}{4}\left(\frac{\cos 5\theta}{5} - \frac{\cos 3\theta}{3} \right) + \cdots \right\} \right] \qquad (11)$$

In order to get the values of arbitrary constants C and D, we shall assume that $q = 0$ at $\theta = \delta$ and $\theta = \pi - \delta$, where δ is a small angle. The reason for taking $\theta = \delta$ and $\theta = \pi - \delta$ instead of $\theta = 0$ and $\theta = \pi$ is clear from the form of q in (11), as at $\theta = 0$ and π, q will become infinite and the motion will be turbulent at these positions. Therefore applying the conditions viz. $q = 0$ at $\theta = \delta, \pi - \delta$ (in order to avoid turbulence at $\theta = 0, \pi$) we get the values of C and D and thus obtain the final solution of (10) in the form.

$$q = \frac{-\mu l_n^2}{16\pi\beta\, r^{2n+3}}\left(a_1\,\theta_n + b_1\,\theta_{n-1} + c_1\,\theta_{n-2} + a_2\,\theta_{n-3} + b_2\,\theta_{n-4} + c_2\,\theta_1 + a_3\,\theta_2 + \cdots \right)$$

$$(12)$$

where $\theta_n = \frac{1}{2n}\left[-\frac{\cot\theta}{\cos\delta}\left(\frac{\cos(2n+1)\delta}{(2n+1)} - \frac{\cos(2n-1)\delta}{(2n-1)} \right) \right.$

$$\left. + \csc\theta\left(\frac{\cos(2n+1)\theta}{(2n+1)} - \frac{\cos(2n-1)\theta}{(2n-1)} \right) \right] \qquad (13)$$

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As l_n is a small quantity, q will also be small and therefore it is not unreasonable to neglect the squares of cross-radial velocity q in the beginning.

For $n = 2, 3$, the cross-radial velocities $[q]_{n=2}$ and $[q]_{n=3}$ will be given by

$$[q]_{n=2} = \frac{\mu l^2_2 \cot \theta}{32 \pi \beta \, r^7} \left\{ \sin^2 \theta \left(\frac{4}{3} - \sin^2 \theta \right) - \sin^2 \delta \left(\frac{4}{3} - \sin^2 \delta \right) \right\} \quad (14)$$

and
$$[q]_{n=3} = \frac{\mu l_3{}^2 \cot \theta}{32 \pi \beta \, r^9} \left[\sin^2\theta \left\{ \left(5 \sin^2 \theta - \frac{21}{5} \right)^2 + \frac{159}{25} \right\} \right.$$

$$\left. - \sin^2 \delta \left\{ \left(5 \sin^2 \delta - \frac{21}{5} \right)^2 + \frac{159}{25} \right\} \right] \quad (15)$$

which show that $[q]_{n=2} = [q]_{n=3} = 0$ at $\theta = \pi/2$ also beside they being zero at fixed boundaries $\theta = \delta, \pi - \delta$

For maximum and minimum values of q, $\frac{dq}{d\theta} = 0$; for which θ is given by

$$12 \sin^6\theta - 17 \sin^4\theta + 4 \sin^2\theta - 3 \sin^4\delta + 4 \sin^2\delta = 0 \quad (16)$$

and $\{150 \sin^8\theta - 293 \sin^6\theta + 174 \sin^4\theta - 24 \sin^2\theta$

$$- 25 \sin^6\delta + 42 \sin^4\delta - 24 \sin^2\delta\} = 0 \quad (17)$$

respectively for $n = 2$ and 3.

The only agreable values of θ satisfying (16) and (17) are respectively

$$[\theta]_{n=2} = 90° \pm 58° \quad (18)$$

$$[\theta]_{n=3} = 90° \pm 64° \quad (19)$$

for each set of which, $\frac{d^2q}{d\theta^2}$ can be seen to positive and negative respectively.

One can see from (14) and (15) that q will remain positive for $\delta < \theta < \pi/2$, zero for $\theta = \pi/2$ and negative for $\pi/2 < \theta < \pi - \delta$, for $n=2$ and 3. It appears that the same will be true for other values of n also.

Physical Picture:—On different longitudnal planes $\phi = $ constant, fluid would be flowing, along different arcs of the circles, towards the latitude $\theta = \pi/2$. The cross-radial velocity will be numerically maximum somewhere between δ and $\pi/2$, and also between $\pi/2$ and $\pi - \delta$, depending upon the value of n. From (18) and (19) it appears that the latitudes of maximum velocity will shift towards $\theta = \delta$

and $\pi - \delta$, as n increases. Also since 'r' occurs in the denominator of q [see equations (14) and (15)], we can see that along every longitudual plane, cross-radial velocity will go on decreasing as we proceed towards the surface of the star; which shows that the star will remain stable. Also, q is a function of μl^2_n which is purely a magnetic term.

Case II:—We shall now consider the case in which the density ρ satisfies the relation.

$$\rho = \frac{\alpha(1+\cos^2\theta)}{r^m}, \text{ (where } m \text{ is a positive integer)}$$

except in a small but finite solid core having constant density surrounding the centre of the star.

In this case equation (7) will become

$$\frac{d^2q}{d\theta^2} + \cot\theta \frac{dq}{d\theta} - q \csc^2\theta = -\left[\frac{k\gamma \alpha^\gamma}{\beta r^{m\gamma - 1}}(1+\cos^2\theta)^{\gamma - 1}\sin 2\theta\right.$$

$$\left. + \frac{\mu l^2_n}{8\pi\beta r^{2n+3}}\left\{a_1 \sin 2n\theta + ...\right\}\right] \qquad (20)$$

The solution of the above equation will be

$$q = \frac{1}{\sin\theta}\left[2C\sin^2\tfrac{1}{2}\theta + 2D\cos^2\tfrac{1}{2}\theta - \frac{k\alpha^\gamma \cos\theta}{\beta r^{m\gamma - 1}}\right.$$

$$\left\{1 + \frac{\gamma}{3}\cos^2\theta + \frac{\gamma(\gamma - 1)}{10}\cos^4\theta + ...\right\}$$

$$- \frac{\mu l_n^2}{16\pi\beta r^{n+2}}\left\{\frac{a_1}{2n}\left(\frac{\cos(2n+1)\theta}{(2n+1)} - \frac{\cos(2n-1)\theta}{2n-1}\right)\right.$$

$$+ \frac{b_1}{2(n-1)}\left(\frac{\cos(2n-1)\theta}{(2n-1)} - \frac{\cos(2n-3)\theta}{2n-3}\right)$$

$$+ \frac{c_1}{2(n-2)}\left(\frac{\cos(2n-3)\theta}{2n-3} - \frac{\cos(2n-5)\theta}{2n-5}\right)$$

$$+ \frac{a_2}{2(n-3)}\left(\frac{\cos(2n-5)\theta}{2n-5} - \frac{\cos(2n-7)\theta}{2n-7}\right)$$

$$+ \frac{b_2}{2(n-4)}\left(\frac{\cos(2n-7)\theta}{2n-7} - \frac{\cos(2n-9)\theta}{2n-9}\right)$$

$$+ \frac{c_2}{2} \left(\frac{\cos 3\theta}{3} - \frac{\cos \theta}{1} \right)$$

$$+ \frac{a_3}{4} \left(\frac{\cos 5\theta}{5} - \frac{\cos 3\theta}{3} \right)$$

$$+ \quad \cdots \cdots \cdots \cdots \cdots \Big\} \Big] \tag{21}$$

Again, we find from (21) that q becomes infinite at $\theta = 0$ and π. Therefore, in order to get the values of arbitrary constants C and D, we assume that $q = 0$ at $\theta = \delta$ and $\pi - \delta$, as in the previous case. With these conditions (21) will become

$$q = \frac{\gamma k a^\gamma \cot \theta}{\beta \, r^{m\gamma - 1}} \left[\left(\frac{1}{3} \cos^2\delta + \frac{\gamma-1}{10} \cos^4\delta + \cdots \right) \right.$$

$$\left. - \left(\frac{1}{3} \cos^2\theta + \frac{\gamma-1}{10} \cos^4\theta + \cdots \right) \right]$$

$$- \frac{\mu l^2{}_n}{16\pi\beta \, r^{2n+3}} \left[-\frac{\cot \theta}{\cos \delta} \left\{ \left(\frac{\cos (2n+1)\,\delta}{2n+1} - \frac{\cos (2n-1)\,\delta}{2n-1} \right) \frac{a_1}{2n} + \cdots \right\} \right.$$

$$\left. + \operatorname{cosec} \theta \left\{ \frac{a_1}{2n} \left(\frac{\cos (2n+1)\,\theta}{2n+1} - \frac{\cos (2n-1)\,\theta}{2n-1} \right) + \cdots \right\} \right] \tag{22}$$

(i) For $n = 2 :-$ $q = \cot \theta \left[\frac{\gamma k a^\gamma}{\beta r^{m\gamma - 1}} \left\{ \left(\frac{1}{3} \cos^2\delta + \frac{\gamma-1}{10} \cos^4\delta + \cdots \right) - \right. \right.$

$$\left. \left(\frac{1}{3} \cos^2\theta + \frac{\gamma-1}{10} \cos^4\theta + \cdots \right) \right\}$$

$$\left. + \frac{3\mu l_2{}^2}{32\pi\beta r^7} \left\{ \sin^2\theta \, (4 - 3 \sin^2\theta) + 3 \sin^4\delta - 4 \sin^2\delta \right\} \right] \tag{23}$$

(ii) For $n = 3$, $q = \cot\theta \left[\frac{k\gamma a^\gamma}{\beta r^{m\gamma - 1}} \left\{ \left(\frac{1}{3} \cos^2\delta + \frac{\gamma-1}{10} \cos^4\delta + \cdots \right) \right. \right.$

$$\left. - \left(\frac{1}{3} \cos^2\theta + \frac{\gamma-1}{10} \cos^4\theta + \right) \cdots \right\}$$

$$+ \frac{\mu l_3{}^2}{32\pi\beta r^9} \left[\sin^2\theta \left\{ \left(5 \sin^2\theta - \frac{21}{5} \right)^2 + \frac{159}{25} \right\} \right.$$

$$\left. - \left(25 \sin^6\delta - 42 \sin^4\delta + 24 \sin^2\delta \right) \right\} \right]$$

From (23) and (24) it is clear that $q = 0$ at $\theta = \pi/2$ also, beside it being zero at $\theta = \delta$, $\pi - \delta$. Obviously for some values of θ, one lying between $\theta = \delta$ and $\pi/2$ and the other between $\theta = \pi/2$ and $\pi - \delta$, q will be numerically maximum which

can be obtained approximately by equating $\dfrac{dq}{d\theta} = 0$.

From (23) and (24), it can be seen that q will remain positive between $\theta = \delta$ and $\pi/2$ but becomes negative between $\theta = \pi/2$ and $\pi - \delta$. Thus the physical interpretation will be more or less the same as in the previous case except with the difference that the cross-radial velocity will comparatively be larger than what we obtained in the previous case.

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ON THE STABILITY OF VISCOUS FLOW BETWEEN TWO CO-AXIAL ROTATING CYLINDERS

By

J. M. GANDHI

Department of Physics, University of Rajasthan, Jaipur
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ABSTRACT

In this paper a new method is described for solving the characteristic value problem underlying the theory of the stability of viscous flow between two co-axial rotating cylinders. The method depends on solving a simpler adjoint system of equations derived by Roberts (1950) and Chandrasekhar (1961). An doubly infinite set of secular determinant has been obtained and it is revealed that the results for first, second, third ... etc. order approximations as calculated from the present secular determinant are identical to the results for second, fourth, six ... etc. order approximations as calculated from the secular determinant obtained by Gandhi and Varma (1963).

1. INTRODUCTION

Chandrasekhar (1961a) has solved the mathematical problem of the stability of viscous flow between two rotating co-axial cylinders. Roberts (1960) and Chandrasekhar (1961a) have derived an adjoint system of equations (two systems of equations are adjoint to each other, if they determine the same value of the characteristic parameter) for the problem in hand. The adjoint system of equations were solved by Gandhi and Varma (1963) who have shown that it is considerably simpler to solve the adjoint system of equations than to solve the original set of equations, and that their method leads to the results of equal precision. By transforming the origin of co-ordinated to lie midway between the two cylinders, the transformed equations are solved using a better trial function. It is revealed that the expressions for the values of T, in first, second, third...etc. order approximations from the present secular equation become completely identical to the expressions for T, in second, fourth, six ... etc. order approximations as obtained from the secular equation derived by Gandhi and Varma (1963).

2. The characteristic value problem and the solution of the adjoint system of equations.

By considering symmetric perturbations of the solution (1) V(r) = Ar +B/r which the Navier-Stokes equations allow for the distribution of the rotational velocity V(r) between two co-axial rotating cylinders (Where A and B are constants, related to the angular velocities Ω_1 and Ω_2, with which the inner and outer cylinders are rotated), one finds that the equations governing the state of marginal stability for the disturbances which are periodic in the axial z direction, with a wave number k, reduces to the solution of pair of equations (Chandrasekhar 1961a).

(2) $(D^2-a^2)^2 u = (1+\alpha z)v.$

(3) $(D^2-a^2) v = -a^2 T u.$

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together with the boundary conditions

(4) $u = Du = v = O$ at $z = O$ and 1.

where $D = d/dz$, $a = \dfrac{k}{R_2 - R_1}$, R_2 and R_1 being the radii of the outer and the

inner cylinders; T is the Taylor's number and $\mu = \Omega_2/\Omega_1$, $\alpha = -(1-\mu)$ and u and v are the amplitudes of the periodically varying velocities in the radial and transverse directions respectively.

It was shown by Roberts (1960) and Chandrasekhar (1961a) that the following set of equations

(5) $(D^2 - a^2)^2 u^* = v^*$.

(6) $(D^2 - a^2) v^* = - a^2 T (1 + \alpha z) u^*$.

together with the boundary conditions

(7) $u^* = Du^* = v^* = O$ for $z = O$ and 1.

are adjoint to the set of equations (2) – (4) *i.e.* they determine the same value of the characteristic parameter T.

Equations (5)–(7) were solved by Gandhi and Varma (1963), and it was shown by them that it is more simpler to solve equations (5) - (7) rather than to solve equations (2) - (4), and yields results of equal precision.

Transforming the origin of z to be midway between two cylinders, equations (5) – (7) become

(8) $(D^2 - a^2)^2 u^* = v^*$.

(9) $(D^2 - a^2) v^* = - Ta^2 (1 + \alpha/2 + \alpha z) u^*$

with the boundary conditions

(10) $u^* = Du^* = v^* = O$ for $z = \pm \frac{1}{2}$.

In this paper we solve equations (8)–(10) instead of solving equations (5) – (7), and show that the results for first, second, third, ... etc. order calculations are identical to the results of second fourth, six, ... etc. order calculations from the secular determinant obtained by Gandhi and Varma (1963).

We assume a Fourier expansion for v^* of the form

(11) $v^* = \sum\limits_{m} [A_m \cos p_m x + B_m \sin g_m x]$.

where

(12) $p_m = (2m - 1) \pi$ and $g_m = 2m \pi$ $(m = 1, 2, ...)$.

so that the boundary conditions on v^* are completely satisfied.

Then we have to solve the equation

(13) $(D^2 - a^2)^2 u^* = \sum\limits_{m=1}^{\infty} (A_m \cos p_m x + B_m \sin g_m x)$.

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subject to the boundary conditions $u^* = Du^* = O$ at $z = \pm \frac{1}{2}$ with the result $(a \neq p_m$ or $g_m)$.

$$(14) \quad u^* = \sum_{m=1}^{\infty} A_m Y_m^2 [a_1^{(m)} \mathrm{Cosh}\, a\, x + a_2^{(m)} x \mathrm{Sinh}\, a\, x + \mathrm{Cos}\, p_m\, x\,]$$

$$+ \sum_{m=1}^{\infty} B_m \varphi_m^2 [b_1^{(m)} \mathrm{Sinh}\, a\, x + b_2^{(m)} x \mathrm{Cosh}\, a\, x + \mathrm{Sin}\, g_m\, x].$$

where

$$(15) \quad Y_m = 1/(p_m^2 + a^2).$$

and

$$(16) \quad Q_m = 1/ (I_m^2 + a^2).$$

The constants of integration appearing in the solution (14) can be evaluated from the boundary conditions with the results

$$a_1^{(m)} = \frac{(-1)^m P_m \mathrm{Sinh}\, a/2}{a + \mathrm{Sinh}\, a}.$$

$$a_2^{(m)} = \frac{-2(-1)^m p_m \mathrm{Cosh}\, a/2}{a + \mathrm{Sinh}\, a}$$

(17)

$$b_1^{(m)} = \frac{(-1)^m g_m \mathrm{Cosh}\, a/2}{\mathrm{Sinh}\, a - a}.$$

$$b_2^{(m)} = \frac{-2(-1)^m I_m \mathrm{Sinh}\, a/2}{\mathrm{Sing}\, a - a}$$

The solution (14) has been written in such a form that the two summations contain even and odd parts of the solution respectively.

Now when v^* and u^* as given by (11) and (14) are substituted into (9), the result must be multiplied by $\cos p_n z$, and $\sin I_n z$ in turn and integrated between $z = -\frac{1}{2}$ and $z = +\frac{1}{2}$. In this manner we obtain a doubly infinite system of linear homogeneous for the constants A_m and B_m,

$$(18) \begin{cases} \sum_{m=1}^{\infty} \left[A_m \left(\frac{\delta_{mN}}{2\Gamma a^2 Y_m^3} - A_{mN} \right) - B_m B_{mn} \right] = 0. \\ \sum_{m=1}^{\infty} \left[A_m C_{mn} - B_m \left(\frac{\delta_{mN}}{2Ta^2 \varphi_m^3} - D_{mn} \right) \right] = 0. \end{cases}$$

where

$$(19) \quad A_{mn} = (1 + \alpha/2) \left[\tfrac{1}{2} \delta_{nm} - \frac{4a(-1)^{n+m} P_m P_n Y_N^2 (1 + \mathrm{Cosh}\, a)}{a + \mathrm{Sinh}\, a} \right]$$

$$(20) \quad D_{mn} = (1 + \alpha/2) \left[\tfrac{1}{2} \delta_{nm} - \frac{4a(-1)^{n+m} g_m g_n \varphi_n^2 (\mathrm{Cosh}\, a - 1)}{\mathrm{Sinh}\, a - a} \right]$$

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(21) $\dot{B}_{mn} = 4\,\alpha\,(-1)^{m+n}\;g_m\,p_n\Bigg[\;\dfrac{1}{(G_m^2 - p_n^2)^2}$

$\qquad + \dfrac{\gamma_n^2}{\text{Sinh } a - a}\left\{\;-\dfrac{a}{2}\,(\text{Cosh } a - 3) + \varphi_n\,\text{Sinh } a\,(3a^2 - g_n^2)\;\right\}\Bigg]$

(22) $C_{mn} = 4\,\alpha\,(-1)^{m+n}\;g_n\,p_m\Bigg[\;\dfrac{1}{(g_n^2 - p_m^2)^2}$

$\qquad + \dfrac{\varphi_n^2}{\text{Sinh } a + a}\left\{\;-\dfrac{a}{2}\,(\text{Cosh } a + 3) + \varphi_n\,\text{Sinh } a\,(3\,a^2 - g_n^2)\;\right\}\;\Bigg]$

The requirements that these constants do not vanish identically lead to the secular equation.

$$(23)\quad \begin{vmatrix} A_{mn} - \dfrac{\delta_{mn}}{2Ta^2\,Y_m^3} & B_{mn} \\[3ex] C_{mn} & D_{mn} - \dfrac{\delta_{mn}}{2Ta^2\,\varphi^3{}_m} \end{vmatrix} = 0.$$

When the secular equation (23) is solved for the various orders of approximation, it is revealed that the results for first order second order, third order, ... etc. approximations are identical to the results for second order, fourth order and six order, ... etc. approximations that will be obtained from the secular equation obtained by Gandhi and Varma (1963).

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ON THE PERIODICITY OF MONSOON FLOWS OF THE GANGA RIVER AT RAIWALA

By

A. P. Bhattacharya, Research Officer, Basic Research Division, Irrigation Research Institute, Roorkee

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ABSTRACT

An attempt was made to examine the periodicity of monsoon flows of the Ganga River for the period 1901-48. Applying Kendall's methods, trend effect was eliminated by a nine-point moving average on the basis of an analysis by the variate-difference method. Three tests of randomness were applied, which clearly brought out that the random portion constituted a major component of the series. Serial correlation coefficients were examined up to the 25th order. It was indicated that the series was generated by an autoregressive scheme. The mean period of oscillations was found to be 5·6 years.

A study of monsoon flow or runoff of the Ganga River at Raiwala was carried out for the months of June to September for the period 1901-48 to detect the existence of cycles, if any, which may be useful in getting some trend for the prediction of the volume and occurrence of monsoon river flow or runoff.

Monsoon runoff is tabulated in Table 1 for the period 1901-48 and is plotted in Figure 1. It will be clear from Figure 1 that monsoon runoff generally went down in the second half of the period under investigation as compared to the first half, the occurrence of monsoon runoff of the order of 10 million cusec days or higher being noticeable only thrice during 1925-1948 as compared to 15 times during 1901-1924. This is a general indication of the progressive lowering of monsoon runoff of the Ganga river during the period 1901-48.

Analytical examination of the behaviour of the series of monsoon runoff of the Ganga for the period 1901-48 was done in accordance with the techniques advocated by Kendall[1,2]. According to the latter, a typical Time Series is composed of three parts :—

    (*a*) a "trend" or long-term movements,

    (*b*) an "oscillation" about the trend of greater or less regularity,

    (*c*) a "random", "irregular" or "unsystematic" component.

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From an examination of the data plotted in Figure 1, it was not possible to detect the existence of any "smooth" or "regular" movements in the series. No attempt was therefore made for trend-fitting.

Years

Graph 1. Graph of Total Monsoon flow of the Ganga River at Raiwala (Hardwar) during the months of June to September (from 1901 to 1948)

In order to study the behaviour of the series, trend-effect was first eliminated by the method of moving averages, as advocated by Kendall. In order to ascertain a lower limit to the degree of the polynomial which may represent the series, which could provide the lower limit of the extent to which moving averages were to be considered, the technique of variate-difference method, advocated by Tintner[3] and also used by Kendall, was adopted. Table 2 gives differences of the series up

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TABLE 1

Residual values of monsoon flow or runoff for the Ganga River at Raiwala (Hardwar) after elimination of trend by a Simple Nine-point Moving Average

Years	Total discharge of Ganga at Raiwala during monsoon in cusec-days $\times 10^4$	Nine-point moving average	Residual	
1	2	3	4	
1901	1923			
1902	884			
1903	932			
1904	1213			
1905	963	1130		—167
1906	1287	1140	(P)	141
1907	881	1185	(T)	—304
1908	1470	1193	(P)	277
1909	1313	1134	(T)	179
1910	1370	1169	(P)	201
1911	1238	1145		93
1912	1000	1149		—149
1913	685	1143	(T)	—458
1914	1275	1085	(P)	190
1915	1071	1056		15
1916	919	1029	(T)	—110
1917	1415	1055	(P)	360
1918	789	1120	(T)	—331
1919	1112	1067	(P)	45
1920	999	1086	(T)	— 87
1921	1228	1090		138
1922	1273	1018	(P)	255
1923	797	1021	(T)	—224
1924	1246	984	(P)	262
1925	954	961		— 7
1926	762	932	(T)	—170
1927	818	868	(P)	— 50
1928	784	867	(T)	— 83
1929	788	840		— 52
1930	970	838	(P)	132
1931	692	840	(T)	—148
1932	789	839		— 50
1933	1006	819	(P)	187
1934	939	811		128
1935	776	755	(T)	21
1936	804	735	(P)	69
1937	604	709	(T)	—105
1938	717	718	(P)	— 1
1939	470	697	(T)	—227
1940	510	711		—201
1941	552	741		—189
1942	1085	761	(P)	324
1943	755	754	(T)	1
1944	902	803		99
1945	1072			
1946	782			
1947	661			
1948	908			

TABLE 2

Differences of the Series of Monsoon Runoff of the Ganga River at Raiwala from 1901 to 1948 in cusec-days × 10⁴

Year	Monsoon runoff in cusec-days × 10⁴	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	2	3	4	5	6	7	8	9	10	11	12
1901	1223	339	387	154	−610	−2479	−6857	−16673	−38422	−84766	−178598
1902	884	−48	233	764	1869	4378	9816	21749	46344	9·832	180357
1903	932	−281	−531	−1105	−2409	−5438	−11933	−24595	−47488	−86525	−150008
1904	1213	250	574	1304	3029	6495	12662	22893	39037	63483	100167
1905	963	−324	730	−1725	−3466	−6167	−10231	−16144	−24446	−36684	−59046
1906	1287	406	995	1741	2701	4064	5913	8302	12238	22362	52175
1907	881	−589	−746	−960	−1363	−1849	−2389	−3936	−10124	−29813	−79884
1908	1470	157	214	403	416	540	1547	6188	19689	50071	106034
1909	1313	−57	−189	−83	−54	−1007	−4641	−13501	−30882	−55963	−826000
1910	1370	132	−106	29	953	3634	8860	16881	25581	26637	−1778
1911	1238	238	−77	982	2681	5226	8021	3700	1056	28415	106133
1912	1000	315	905	1699	2545	2795	689	−7644	−29471	−77718	−174387
1913	685	−590	794	−846	−250	2116	8323	21827	28247	96669	181144
1914	1275	204	52	596	−2366	−6207	−13504	−26420	−48422	−84475	−139443
1915	1071	152	648	1770	3840	7297	12016	22002	36053	54968	72157
1916	919	−496	−1122	−2071	−3456	−5619	−9086	−14051	−18915	−17189	8130
1917	1415	626	949	1385	2163	3467	4965	4864	−1726	−25319	−85248
1918	789	−323	−436	−778	−1304	−1493	101	6590	23593	59929	127824
1919	1112	113	342	526	189	−1594	−6489	−17003	−36356	−67895	−115274
1920	999	−229	−184	337	1783	4895	10514	19333	31559	47379	67438
1921	1246	−45	−521	−1446	−3112	−5619	−8819	−12226	−15820	−20059	26669
1922	1273	476	925	1666	2507	3200	3407	3594	4239	6610	15016
1923	797	−449	−741	−841	−693	−207	187	645	2371	8406	26605
1924	1240	292	100	−148	−486	−20	458	1726	6035	18199	46536

Year											
1925	954	192	248	338	466	478	—1268	—4309	—12164	—25337	—56532
1926	762	—56	—90	—138	12	790	—3041	—7855	16173	48195	42887
1927	818	34	38	—140	—778	—2251	—4814	—8318	—12022	—14692	—15406
1928	784	4	178	638	1473	2563	3504	3704	2670	714	619
1929	788	—182	—460	835	—1090	941	200	1034	1956	95	10860
1930	970	278	375	255	149	—741	1234	922	1861	10955	34855
1931	692	97	120	404	592	493	—312	—2783	—9094	—23953	56854
1932	789	—217	—284	188	99	805	2471	6311	14859	32901	69181
1933	1006	67	—96	—287	—706	—1666	—3840	—8548	—18042	—36280	—71543
1934	939	163	191	419	960	2174	4708	9494	18238	35263	72046
1935	776	—28	—228	—541	—1214	—2534	—4786	—8744	—17025	—36783	—84197
1936	804	—200	313	673	1320	2252	3958	8281	19758	47414	106527
1937	604	—113	—360	—647	—932	—1706	—4323	—11477	—27656	—59113	—112725
1938	717	247	287	285	774	2617	7154	16179	31457	53612	80585
1939	470	—40	2	—489	—1943	—4537	—9025	—15278	—22155	—26873	
1940	510	—42	491	1354	2694	4488	6253	6870	4818		
1941	552	—533	—863	—1340	—1794	—1765	—624	2059			
1942	1085	330	477	454	29	—1141	—2683				
1943	755	—147	23	483	1112	1542					
1944	902	—170	—460	—629	—430						
1945	1072	290	169	—199							
1946	782	121	368								
1947	661	—247									
1948	908										

to the tenth order. This is aimed at an examination of the random component of the series. It is assumed (by Kendall) that successive differencing of the series will gradually eliminate the polynomial element but will not reduce the random element correspondingly. Kendell has given formulae for the derivation of moments. According to Kendell, for calculating the moment of any order, we have to consider the sum of squares of differences of that order as also the factor $\left(2^r_r \right)$ which for $r = 1$ to 10 has the following values :—

r	$\left(2^r_r \right)$
1	2
2	6

r	$\left(2^r_r \right)$
3	20
4	70
5	252
6	924
7	3,432
8	12,870
9	48,620
10	184,756

Sums of squares in the various columns of Table 2 were found to be as follows :—

$$S_1 = 3,772,637$$
$$S_2 = 11,599,364$$
$$S_3 = 39,247,256$$
$$S_4 = 139,421,139$$
$$S_5 = 506,190,960$$
$$S_6 = 1,854,193,850$$
$$S_7 = 6,815,744,720$$
$$S_8 = 25,082,665,782$$
$$S_9 = 92,017,270,518$$
$$S_{10} = 324,437,139,582$$

To obtain second moments, we divide by 48—j and then, to obtain the estimate of V, by $\left(2\dfrac{j}{j} \right)$ We get the following thereby :—

j	Estimate
1	40,134
2	42,027
3	43,608
4	45,267
5	46,714
6	47,779
7	48,438
8	48,723
9	48,528
10	46,211

Normally, the variances should go down gradually and we should stop differencing at the stage when the variances become more or less stationary. Discrepancies of the kind met with herein are not uncommon and have been noticed by Kendall as well in short series of the kind studied. It may therefore be reasonable to assume that variances get stabilized on reaching the ninth order. It was on this basis that it was decided to adopt nine point moving averages for trend elimination. Incidentally, the variance of the series is 60,069. The mean square of the first differences, divided by 2, is 40,134 so that only one-third of the variance is eliminated by first differencing indicating again that the differencing (and consequently moving averages) has to be done up to a much higher order.

After the elimination of the trend-effect, an examination of the residual series was made with a view to get some idea regarding the oscillatory movements and the periodicity thereof. Randomness was first tested by counting the occurrence of "peaks" or "troughs", which are denoted by P or T respectively in column 4 of Table 1. The number of turning points is 28 in a series of 40 terms. Expected number of such points is (2/3) (N— 2)=25, where N is the number of terms of the series. Now variance of the distribution = (16M—29)/90 = 2·35, so the standard deviation = 1·533. Thus the difference of the actual number of turning points from the expected number is not higher than twice the standard deviation, indicating thereby the randomness of the series.

A second test of randomness, based on the distribution of phase lengths, was also applied. The number of years between a peak or a trough is known as the duration of a phase and is denoted by d. The probability of a phase d in a series of N is :—

$$\frac{6 \left(d^2 + 3d + 1 \right) (N\text{-}d\text{-}2)}{(d + 3) \, ! \, (2N\text{-}7)}$$

Hence, we get for the duration of phases :—

			Observed	Predicted
$d = 1$	...	...	19	17·11
$d = 2$	...	...	6	7·32
$d = 3$ and over	...	...	2	2·57
Total		...	27	27

By χ^2 — test for the goodness of fit, where $\chi^2 = \delta \left(\dfrac{x^2}{m} \right)$ if m is the number expected and $m + x$ the number observed, $\chi^2 = 0.573^{(m)}$ for 2 degrees of freedom. From tables, we get P between 0·70 and 0·80. This also points to the randomness of the series.

A third test of randomness was applied by calculating the Spearman coefficient of rank correlation, ρ, which is defined as below.

$$\rho = 1 - \frac{6 \, \Sigma \, (d^2)}{n^3 - n}$$

For applying this test, the series of residuals was arranged in an ascending order and the rank of each number was determined thereby. The difference between the number and its rank is denoted as d, while the number of terms in the series is denoted as n. The value of $\Sigma(d)^2$ was found to be 11,461, while $n = 40$, ρ was worked out to be 0·0751. For applying t-test, the value of t was obtained as

$$t = \rho \frac{(n - 2)^{\frac{1}{2}}}{(1 - \rho^2)} = 0.46421$$

for $v = 38$, where v = degrees of freedom = 38. From the tables, the probability of obtaining such a value or greater is found to be 0·325, which points to the insignificance of the rank correlation coefficiant, bringing out the randomness of the series of residuals of Table 1.

The application of the three tests as above clearly indicated a major component of the series of residuals obtained by the elimination of the trend effect to be random. In order to get an idea of the average period of oscillations which were not expected to be regular on account of the predominance of the random component, serial correlation coefficients of the series of residuals were worked out up to the 25th order, vide Table 3.

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TABLE 3

Serial correlation coefficients of the series of monsoon flows or runoffs of the Ganga River (from 1901 to 1948) after the elimination of trend-effects by nine-point moving average.

Order of correlation, k		Serial correlation coefficient, r_k
1	...	−0·247
2	...	−0·040
3	...	−0·083
4	...	−0·425
5	...	0·048
6	...	−0·0041
7	...	−0·073
8	...	0·150
9	...	−0·066
10	...	−0·137
11	...	0·160
12	...	−0·082
13	...	0·352
14	...	0·100
15	...	−0·197
16	...	0·154
17	...	−0·407
18	...	0·039
19	...	0·040
20	...	−0·052
21	...	0·037
22	...	−0·034
23	...	−0·083
24	...	−0·206
25	...	0·271

A correlogram which is the diagram obtained by graphing r_k (serial correlation coefficient) against k (the order of the serial correlation coefficient) as abscissa and joining the points each to the next was also worked out for the series as in Graph 2. The correlogram of a series generated by moving averages, though it may oscillate, will vanish after a certain point ; that of a series of harmonic terms will oscillate, but will not vanish or be damped ; that of the autoregressive scheme will oscillate and will not vanish, but be damped. The correlogram therefore offers a theoretical basis for discriminating between the three types of oscillatory series.

The correlogram of the series as in Graph 2 suggests the operation of an autoregressive scheme as we find both oscillation and damping. For an autoregressive series, the mean period for the autoregressive part of the series is

$$2\,\pi/\text{arc}\ \cos.\left(\frac{-a}{2\sqrt{b}}\right), \quad \text{where} \quad a = -\frac{r_1\,(1-r_2)}{1-r_1^2}, \quad b = -1 + \frac{1-r_2}{1-r_1^2},$$

r_1 and r_2 being serial correlation coefficients of the first and second order. Now $r_1 = -0.247$ and $r_2 = -0.040$. So $a = 0.253$, $b = 0.0223$. The mean period is therefore $2\,\pi/\cos^{-1}(0.84709) = 180^\circ/32.10^\circ = 5.6$ years.

Values of k
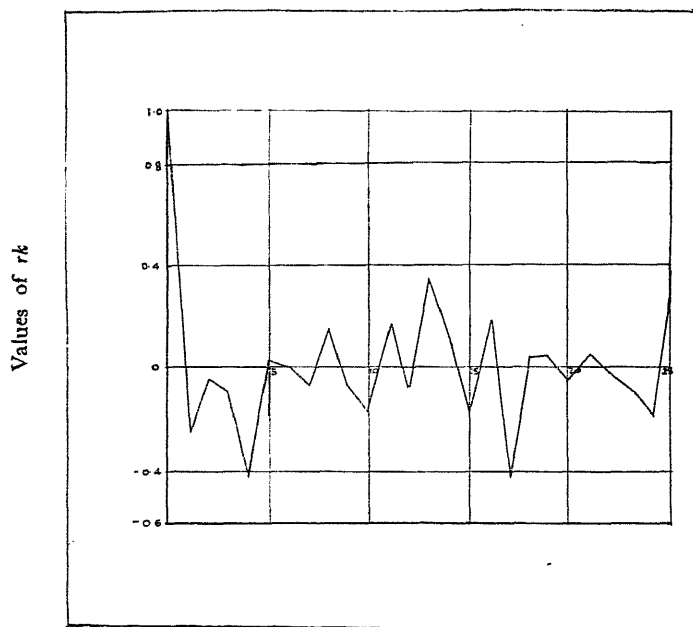
Graph 2. Correlogram of Series of Total Monsoon flow of Ganga River at Raiwala (Hardwar)

It is therefore indicated that the mean period of oscillatory movements of the series, generated after the elimination of trend-effect, of monsoon flow or runoff of the Ganga is 5.6 years. It is interesting to note that from Graph 1, it is apparent that excluding ripples there are 10 peaks so that the mean period of oscillations between upcrosses is indicated to be 4.3 years. It may also be observed that a major portion of the series of residuals obtained after eliminating trend-effect is random.

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THE STABILITY OF GRAVITATING CYLINDER IN THE PRESENCE OF MAGNETIC FIELDS

By

J. M. GANDHI *and* B. P. VINAYAK

Dept. of Physics, University of Rajasthan, Jaipur

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ABSTRACT

We study the stability of an infinitely long gravitating cylinder of incompressible, inviscid and infinitely conducting fluid in the presence of a magnetic field having both poloidal (of the form $H_z = A (R_o^2 - \gamma^2)^{1/2}$) and toroidal (of the form $H\theta = A\gamma$) components. It has been shown that field has a stablizing effect on the cylinder and the value of root mean square mangnetic field in side the cylinder is lower tnan the models of Chandersekhar and Fermi, Auluk and Nayyer, Auluck and Kothari (for poloidal fields) but is higher than in the models of Auluck and Kothari (for toroidal fields).

I. INTRODUCTION

The problem of the effect of magnetic fields on the gravitational stability of an infinitely long cylinder, the material of which is assumed to be incompressible, inviscid and infinitely conducting has recently been studied by various authors Chandrasekhar and Fermi (1953), Auluck and Kothari (1957), Trehan (1958), Auluck and Nayyer (1960). These authors have shown that magnetic field increases the stability of the cylinder. The magnetic field in case of Chandarsekhar and Fermi (Later to be denoted by C. F.) was a uniform longitudnal one which Auluck and Kothari (Later to be denoted by A. K.) have considered purely to roidal and purely poloidal components, Trehan (1958) has considered force free magnetic field. Auluck and Nayyer (1960) have considered a magnetic field having both the poloidal and toroidal components. Gandhi (1960) has discussed general poloidal field of the form $H_z = A (R_o^2 - \gamma^2)^N$ which includes the models of C. F. (1953), and A. K. (1957) as special cases when $N = O$ and $N = 1$, respectively ; and it is shown that as the value of N- increases, the value of root mean square of magnetic field inside the cylinder continuously increases.

We in this paper consider a magnetic field having both poloidal (of the form $H_z = A (R_o^2 - \gamma^2)^{1/2}$ and toroidal (of the form $H\theta = A\gamma$) For our model we have shown that field has a maximum stablizing effect. It is quite interesting to note that the introduction of a toroidal field in presence of a poloidal field, can increase the stablity more than only a poloidal field would have done.

II. EQUILIBRIUM CONDITIONS

We consider a gravitating cylinder of infinite length and radious R_o with constant density ρ, the material of which is assumed to be incompressible, inviscid and infinetely conducting. If H is a magnetic field produced by a current of density j flowing in the liquid, then the field Equation in the steady state are

(1) $div\ H = o$

(2) $Curl\ H = 4\ \pi\ j$

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If we assume axial symmetry, the field H can be derived from two scalar function U and V which are azimuth independent (Auluck & Kothari 1957) Taking the axis of the cylinder as Z-axis, the component of the magnetic field in cylindrical coordinates (R, Q, Z), are

$$(3) \quad H_\gamma = \frac{1}{\gamma} \frac{\partial U}{\partial Z}, \quad H_\theta = \frac{V}{\gamma}, \quad H_z = \frac{1}{\gamma} \frac{\partial U}{\gamma}$$

Where U and V are functions of γ and z only. The Equation of mechanical equlibrium of the Cylinder are

$$(4) \quad grad\,(P - \rho\,\Omega) = j \times H$$

$$\triangle^2 \Omega = 4\,\pi\,G\,\rho$$

The condition of equlibrium Auluck and Nayyer (1960) are,

$$(5) \quad \frac{\partial\,(U, V)}{\partial\,(\gamma, Z)} = 0$$

$$(6) \quad \partial \left\{ \frac{1}{\gamma^2} \left(\triangle U + V \frac{\partial V}{\partial U} \right), U \right\} \Big/ \partial\,(\gamma, z,) = 0$$

Where

$$\triangle U = \frac{\partial^2 U}{\partial \gamma^2} - \frac{1}{\gamma} \frac{\partial U}{\gamma} + \frac{\partial^2 U}{\partial Z^2}$$

Thus U and V satisfy the relation

$$(7) \quad \triangle U + V \frac{\partial V}{\partial U} = \gamma^2 \frac{\partial f(U)}{\partial U}$$

Also from (4) if can be proved that (Gandhi 1960)

$$(8) \quad P = \pi\,G\,\rho^2\,(R_o{}^2 - \gamma^2) - \frac{f(U)}{4\,\pi} + const.$$

Now for true equilibrium the pressure should vanish at the boundry of the cylinder and thus is possible by suitably choosing the constant in (8), $f(u)$ need not be zero at the boundary.

Let us put

$$(9) \quad f(U) = A^2\,\gamma^2 + 3\,A\,\sin^{-1} \frac{1}{R_o} \left[R_o{}^2 - \left(\frac{U}{A} \right)^{2/3} \right]^{1/2}$$

$$(10) \quad V = A\,\gamma^2$$

Now for true equilibrium pressure at boundary should vanish and constant in (8) should be

$$A^2 R_o^2/4 \ \pi \ + \ 3 \ A/8$$

Substituting (9) and (10) in (7) we wet

(11) $$\frac{\partial^2 U}{\partial \gamma^2} - \frac{1}{\partial} \frac{\partial U}{\partial \gamma} - 1 \ / \ \left\{ 1 - \frac{1}{R_o{}^2} \left[R_o{}^2 - \left(\frac{U}{A} \right)^{2/3} \right] \right\}^{1/2} = 0$$

Now it can be seen that the solution of (11) so that $\left(\dfrac{\partial V}{\partial \gamma} \right)_{\gamma \ = \ R_c} = 0,$

a condition required for the continuity of magnetic field at the boundry is

(12) $$U = K \left(R_o{}^2 - \gamma^2 \right)^{3/2}$$

Then corresponding field components are

(13) $$H_x = A \left(R_o \cdot \gamma^2 \right)^{1/2}$$
$$A = -3K$$

III. INVESTIGATION OF THE STABILITY

To investigate whether equilibrium configuration is stable or unstable, we deform the cylinder in such a way that the boundary becomes

(14) $$\gamma = R + a \cos (k Z)$$

Where $a/k \leqslant 1$ and k is the wave number of disturbence in the Z-direction. Since we are the assuming the liquid to be incompressible, the mean radius R of the cylinder in the perturbed state is related to the unperturbed radius by the relation.

(15) $$R_o{}^2 = R^2 + a^2/2$$

Following G. F. (1953), an arbitrary deformation of an incompressible body can be realized by applying at each point of the body a displacement ξ whose components are given by

(16) $$\xi_\gamma = \frac{a \ I_1 (k \ \gamma) \cos (k \ z)}{I_1 (k \ R_o)} \ , \quad \xi_\theta = 0$$

and $$\xi_z = - \frac{a \ I_1 (k \ \gamma) \sin (k \ z)}{I_1 (k \ R_o)}$$

It has been proved by G. F. (1953) that the change in gravitational energy per unit length of the cylinder resulting from deformation given by (14) is

(17) $$\triangle \Omega = 2 \ \pi^2 \ \rho^2 \ G \ R_o{}^2 \ [\tfrac{1}{2} - I_0(x) \ K_0(x)] \ a^2$$

Where $k \gamma = x$

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Since the component H_θ of the field does not vanish (Although H is continuous at the boundary) While component H_z of the field vanishes at the boundary, we have to find the change in magnetic energy separately due to H_θ component & H_z component of the field.

The change in magnetic energy due to component was found by A. K. (1957). It is

(18)
$$\Delta M_\theta = \tfrac{1}{4} \cdot A^2 R_0^2 a^2$$

While change in magnetic energy due to component of the form given by (13) has been found to be given by Gandhi (1960)

(19)
$$\Delta M_z = \frac{A^2 a^2 k^2}{8\, I_1^2(x)} \int_0^{R_0} \gamma \,(R_0^2 - \gamma^2)\, [I_0^2(x) + I_1^2(x)]\, d\gamma$$

This has been simplified by Gandhi (1960) and we get

(20)
$$\Delta M_z = \frac{A^2 a^2 R_0^2}{8}$$

Hence total change of magnetic energy is given by

(21)
$$\Delta M' = \tfrac{3}{8} \cdot A^2 R_0^2 a^2$$

The value of the root mean square magnetic field is found to be given by

(22)
$$\overline{H}^2 = A^2 R_0^2$$

In view of (22), (21) becomes

(23)
$$\Delta M' = \tfrac{3}{8} \cdot a^2 \, \overline{H}^2$$

so that total change of energy is given by

(24)
$$\Delta M^1 + \Delta \Omega = \tfrac{3}{8} \cdot a^2 \, \overline{H}^2 + 2\,\pi\, \rho^2\, G\, R_0^2\, [\tfrac{1}{2} - I_0(x)\, K_0(x)]\, a^2$$

(25)   Letting $H_s^2 = 16\,\pi^2\, G\, \rho^2\, R_0^2$

Expression (24) becomes

(26)
$$\Delta M' + \Delta \Omega = \frac{H_s^2}{8} \left\{ \tfrac{1}{2} - I_0'(x)\, K_0(x) + 3 \left(\frac{\overline{H}}{H_s} \right)^2 \right\} a^2$$

Following C. F. (1953) one can show that the equation

(27)
$$\tfrac{1}{2} - I_0(x)\, K_0(x) + 3 \left(\frac{\overline{H}}{H_s} \right)^2 = 0$$

allows a single possible root. If we denote this root by x^* we have

$$\triangle M' + \triangle \Omega > 0 \qquad \text{for} \quad x > x^*$$

$$< 0 \qquad \text{for} \quad x < x^*$$

Hence for the given value of magnetic field the cylinder is stable for all transverse deformations with $k > x^*/R_0$ for all modes of deformations with wave length less than

$$\lambda = 2 \pi R_0/x^*$$

It was shown by Gandhi (1962) that the asymtotic expressions for the wave numbers x^* & x_m at with gravitational instability first sets in and at which it is maximum for an infinitely long gravitating cylinder of an inviscid, incompressible fluid of infinite electrical conductivity with prevelent magnetic fields, are given by

$$(29) \qquad x^* = \cdot 6811 \exp \left\{ - f(0) \right\} \frac{< \bar{H} >^2}{H_s^2}$$

$$(30) \qquad x_m = 0 \cdot 4131 \exp \left\{ - f(0) \right\} \frac{< \bar{H} >^2}{H_s^2}$$

Where $f(x)$ is a function which appears in the characteristic equation and is defined by

$$(31) \qquad f(x) \frac{< \bar{H} >^2}{H_s^2} = I_0(x) K_0(x) - \tfrac{1}{2}$$

Comparing equation (31) with (27) we get

$$f(x) = 3 \quad \& \text{ hence}$$

$$f(0) = 3$$

So that form (29) and (30) we have

$$(32) \qquad x^* = 0 \cdot 6811 \, e^{- 3 \, (\bar{H}/H_s)^2}$$

$$(33) \qquad x_m = 0 \cdot 4131 \, e^{- 3 \, (\bar{H}/H_s)^2}$$

The following table will give the dependence of $(\bar{H}/H_s)$ on the various values of x^*. The table is self explainatory.

TABLE

$x*$	Poloidal $\bar{H}/Hs$ C. F.	Poloidal $\bar{H}/Hs$ G.	Poloidal $\bar{H}/Hs$ A. K.	Toroidal $\bar{H}/Hs$ A. K.	Both Polo. & toroidal $\bar{H}/Hs$ G. V.	Both Polo. & toroidal. $\bar{H}/Hs$ A. N.
1·067	0	0	0	0	0	0
0·9	0·2028	0·2124	0·2176	0·1503	0·1736	0·3127
0·832	0·2500	0·2625	0·2682	0·1845	0·2190	0·3682
0·8	0·2721	0·2823	0·2873	0·1997	0·2305	0·3955
0·5	0·3839	0·4915	0·4952	0·3473	0·4003	0·6722
0·2	0·7949	0·7970	0·7980	0·5636	0·6512	1·0770
0·1	0·9828	0·9832	0·9834	0·6954	0·8036	1·2930

The sixth column gives the values of H/Hs as calculated from (27) while the last column gives the values of H/Hs A. N. for a magnetic field having both poloidal and toroidal component other parts of the table are self explainatory.

ACKNOWLEDGMENTS

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THEOREMS CONCERNING BESSEL TRANSFORMS

By

P. N. RATHIE

Department of Mathematics, Faculty of Engineering, University of Jodhpur, Jodhpur

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ABSTRACT

In this note six theorems on Meijer Transform defined by (1·2) have been proved. The results obtained are quite general and their particular cases give rise to several results given earlier by Bhonsle, Sharma and Verma.

1. Introduction. Meijer (3) gave the generalization of the classical Laplace Transform

$$L\left\{f; p\right\} = \int_0^\infty e^{-pt} f(t)\, dt, \tag{1·1}$$

in the form

$$K_\mu\left\{f; p\right\} = \int_0^\infty (pt)^{\frac{1}{2}} K_\mu(pt) f(t)\, dt. \tag{1·2}$$

The Hankel transform, H-transform and the Y- transform of a function $f(t)$ have been defined by

$$H_\nu\left\{f; p\right\} = \int_0^\infty (pt)^{\frac{1}{2}} J_\nu(pt) f(t)\, dt, \tag{1·3}$$

$$S_\nu\left\{f; p\right\} = \int_0^\infty (pt)^{\frac{1}{2}} H_\nu(pt) f(t)\, dt, \tag{1·4}$$

and

$$T_\nu\left\{f; p\right\} = \int_0^\infty (pt)^{\frac{1}{2}} Y_\nu(pt) f(t)\, dt, \tag{1·5}$$

respectively.

When $\mu = \pm\frac{1}{2}$, (1.2) reduces to $\sqrt{\dfrac{\pi}{2}}$ times (1.1) by virtue of the well-known identity

$$K_{\pm\frac{1}{2}}(x) = \left(\frac{\pi}{2x}\right)^{\frac{1}{2}} e^{-} .$$

In what follows n and s are positive integers, the symbol $\triangle(n; \alpha)$ denotes the set of parameters

$$\frac{\alpha}{n}, \frac{\alpha+1}{n}, \ldots\ldots, \frac{\alpha+n-1}{n},$$

and A, B, C represent the following quantities

$$\sqrt{\frac{\pi}{2}} \ (2n)^{p+\frac{1}{2}} \ (2\pi)^{\frac{1}{2}-n} \ p^{-p-3/2},$$

and

$$\pi^{1-n} \ 2^{p-n/2s} \ {}^{-n+\frac{1}{2}} \ n^{p-n/2s+\frac{1}{2}} \ p^{-p+n/2s-1},$$

$$\pi^{1-n} \ 2^{p+n/2s} \ {}^{-n+\frac{1}{2}} \ n^{p+n/2s+\frac{1}{2}} \ p^{-p-n/2s-1},$$

respectively.

2. We shall require the following results which follow from an integral given by Saxena [(4), p 401].

$$\int_0^\infty t^{p+\frac{1}{2}} \ K_\mu \ (pt) \ J_\nu \ (2a^{-\frac{1}{2}} \ t^{-n/s}) \, dt$$

$$= A. \ G_{0, \ 2s+2n}^{s+2n, \ 0} \left[\frac{s^{-2s}}{a^s} \left(\frac{p}{2n} \right)^{2n} \ \Bigg| \ \Delta \left(n; \frac{3+2p\pm2\mu}{4} \right), \ \Delta \left(s; \pm \frac{\nu}{2} \right) \right] \quad (2.1)$$

for $a > 0$, $R(p) > 0$, $R\left(s(p\pm\mu) + \dfrac{3(s+n)}{2}\right) > 0$.

$$\int_0^\infty t^{p+\frac{1}{2}} \ K_\mu \ (pt) J_\nu \ (2a^{\frac{1}{2}} \ t^{n/s}) \, dt$$

$$= A. \ G_{2s, \ 2n}^{2n, \ s} \left[\frac{s^{2s}}{a^s} \left(\frac{p}{2n} \right)^{2n} \ \Bigg| \ \begin{array}{l} \Delta(s; 1-\nu/2), \ \Delta(s; 1+\nu/2) \\ \Delta\left(n; \dfrac{3+2p\pm2\mu}{4}\right) \end{array} \right] \quad (2.2)$$

for $a > 0$, $R(p) > 0$, $R\left(s\rho \pm s\mu\right) + n\gamma + \dfrac{3s}{2} > 0$.

$$\int_0^\infty t^{p+\frac{1}{2}} \ K_\mu \ (pt) \ Y_\nu \ (2a^{-\frac{1}{2}} \ t^{-n/}) \, dt$$

$$= A. \ G_{s, \ 3s+2n}^{2s+2n, \ 0} \left[\frac{s^{-2s}}{a^s} \left(\frac{p}{2n} \right)^{2n} \ \Bigg| \ \begin{array}{l} \Delta(s; -\nu/2-\frac{1}{2}) \\ \Delta\left(n; \dfrac{3+2p\pm2\mu}{4}\right), \end{array} \right.$$

$$\left. \Delta(s; \pm\nu/2), \ \Delta\left(s; -\frac{\nu}{2}-\frac{1}{2}\right) \right] \quad (2.3)$$

for $a > 0$, $R(p) > 0$, $R\{s\rho\pm s\mu + 3(s+n)/2\} > 0$.

$$\int_0^\infty t^{p+\frac{1}{2}} \ K_\mu \ (pt) \ Y \ (2a^{\frac{1}{2}} \ t^{n/s}) \, dt$$

$$= A. \ G_{3s, \ 2n+s}^{2n, \ 2s} \left[\frac{s^{2s}}{a^s} \left(\frac{p}{2n} \right)^{2n} \ \Bigg| \ \begin{array}{l} \Delta(s; 1\pm\nu/2), \ \Delta(s; 3/2+\nu/2) \\ \Delta\left(n; \dfrac{3+2p\pm2\mu}{4}\right), \ \Delta(s; 3/2+\nu/2) \end{array} \right] \quad (2.4)$$

for $a > 0$, $R(p) > 0$, $R(\rho s \pm \mu s \pm n\nu + 3s/2) > 0$.

$$\int_0^\infty t^{\rho+\frac{1}{2}} K_\mu(pt) H_\nu(2a - \tfrac{1}{2}t - n/s)\, dt$$

$$= A.\ G_{s,\ 3s+2n}^{s+2n,\ s}\left[\ \frac{s^{-2s}}{s}\cdot\left(\frac{p}{2n}\right)^{2n}\ \middle|\ \begin{array}{l}\triangle(s; \nu/2+\tfrac{1}{2})\\[6pt] \triangle\left(n; \dfrac{3+2\rho\pm2\mu}{4}\right),\end{array}\right.$$

$$\left.\triangle(s; \nu/2+\tfrac{1}{2})\ \triangle(s; \pm\nu/2)\ \right] \tag{2.5}$$

for $a > 0$, $R(p) > 0$, $R\{s\rho\pm s\mu + 3(s-n)/2\} > 0$.

$$\int_0^\infty t^{\rho+\frac{1}{2}} K_\mu(pt) H_\nu(2a^{\frac{1}{2}} t^{n/s})\, dt$$

$$= A.\ G_{3s,\ s+2n}^{s+2n,\ s}\left[\ \frac{s^{2s}}{a^s}\left(\frac{p}{2n}\right)^{2n}\ \middle|\ \begin{array}{l}\triangle(s; \tfrac{1}{2}-\nu/2),\ \triangle(s;, 1\pm\nu/2)\\[6pt] \triangle\left(n; \dfrac{3+2\rho\pm2\mu}{4}\right),\ \triangle(s; \tfrac{1}{2}-\nu/2)\end{array}\right] \tag{2.6}$$

for $a > 0$, $R(p) > 0$, $R(s\rho\pm s\mu + n\nu + n \pm 3s/2) > 0$.

3. *Theorem 1*: If $t^\rho f(t^{-n/s})$ and $H_\nu\{f; z\}$ belong to $L(0, \infty)$,

$R(p)\ R > 0$, $R(\nu) > -\tfrac{1}{2}$, $R(2s\rho \pm 2s\mu + 3s + 2n) > 0$,

then

$$K_\mu\left\{t^\rho f(t^{-n/s}); p\right\} = B.\int_0^\infty z^{\frac{1}{2}} H_\nu\{f; z\}\times$$

$$\times G_{0,\ 2s+2n}^{s+2n,\ 0}\left[\ \left(\frac{p}{2n}\right)^{2n}\left(\frac{z}{2s}\right)^{2s}\ \middle|\ \triangle\left(n; \dfrac{3+2\rho-n/s\pm2\mu}{4}\right),\ \triangle(s; \pm\nu/2)\ \right]\ dz. \tag{3.1}$$

Proof: By Hankel's inversion formula, we have

$$f(t) = \int_0^\infty (tz)^{\frac{1}{2}} J_\nu(tz) H_\nu\left\{f; z\right\}\cdot dz \tag{3.2}$$

and by hypothesis

$$K_\mu\left\{t^\rho f(t^{-n/s}); p\right\} = \int_0^\infty (pt)^{\frac{1}{2}} K_\mu(pt) t^\rho f(t^{-n/s})\, dt \tag{3.3}$$

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Substituting the value of $f(t)$ from (3·2) in (3.3), interchanging the order of integration and evaluating the t-integral by (2.1), we arrive at the result.

Corollary:— For $n = s = 1$, (3.1) reduces to a theorem due to Verma [(6), *p.* 98].

4. Theorem 2: If $t^p\ f(t^{n/s})$ and $H_\nu\ \{f; z\}$ belong to L (o, ∞),

$R(p) > o$, $R(\nu) > -\frac{1}{2}$, $R(s p \pm s\ \mu + n\nu + n/2 + 3s/2) > o$,

then

$$K_\mu \left\{ t^p\ f(t^{n/s}); p \right\} = C. \int_0^\infty z^{\frac{1}{2}}\ H_\nu\ \{f; z\} \times$$

$$\times\ G_{2s,\ 2n}^{2n,\ s} \left[\left(\frac{p}{2n}\right)^{2n} \left(\frac{2s}{z}\right)^{2s} \Big| \begin{array}{c} \triangle\ (s;\ 1 - \nu/2),\ \triangle\ (s;\ 1 + \nu/2) \\ \triangle\left(n;\ \dfrac{3 + 2p + n/s \pm 2\mu}{4}\right) \end{array} \right]\ dz \qquad (4·1)$$

Proof:—Proof of this theorem is exactly similar to theorem 1. Instead of (2.1) we shall use (2.2).

Corollary:—For $n = s = 1$, (4.1) reduces to the following result recently given by Sharma [(5), *p.* 108], after a little simplification.

If $t^p\ f(t)$ and $H_\nu\ \{f; z\}$ belong to L (o, ∞), $R(p) > o$, $R(\nu + \frac{1}{2}) > o$,

$R(\nu \pm \mu + p + 2) > o$, then

$$K_\mu \left\{ t^p\ f(t); p \right\} = 2^p\ p^{-p - \nu - 3/2}\ \frac{\Gamma\{\frac{1}{2}(p \pm \mu + \nu + 2)\}}{\Gamma(\nu + 1)} \times$$

$$\int_0^\infty t^{\nu + \frac{1}{2}}\ H_\nu\ \{f; z\}\ {}_2F_1\left[\frac{1}{2}(p \pm \mu + \nu + 2);\ 1 + \nu;\ -\frac{z^2}{p^2} \right]\ dz.$$

Further taking $\mu = \pm\frac{1}{2}$, we get a result recently given by Bhonsle [(1), *p.* 114], after a little adjustment.

5. Theorem 3:— If $t^p\ f(t^{-n/s})$ and $S_\nu\ \{f; z\}$ belong to L (o, ∞),

$R(p) > o$, $-\frac{1}{2} < R(\nu) < \frac{1}{2}$, $R(2s \varepsilon \pm 2s\mu + 3s + 2n) > o$,

then

$$K_\mu \left\{ t^p\ f(t^{-n/s}); p \right\} = B. \int_0^\infty z^{\frac{1}{2}}\ S_\nu\ \{f; z\} \times$$

$$G^{2s+2n,\,0}_{s,\,3s+2n}\left[\left(\frac{p}{2n}\right)^{2n}\left(\frac{z}{2s}\right)^{2s}\;\middle|\;\begin{array}{l}\Delta\left(s;-v/2-\tfrac{1}{2}\right)\\[4pt]\Delta\left(n;\dfrac{3+2\rho-n/s\pm2\mu}{4}\right),\end{array}\right.$$

$$\left.\Delta\left(s;\pm v/2\right),\;\Delta\left(s;-v/2-\tfrac{1}{2}\right)\right]dz \tag{5.1}$$

Proof:—We have

$$f(t)=\int_{0}^{\infty}(tz)^{\frac{1}{2}}\,Y_{v}\,(tz)\,S_{v}\,\{f;z\}\,dz \tag{5.2}$$

and

$$K_{\mu}\left\{t^{\rho}\,f\,(t^{-n/s});\,p\right\}=\int_{0}^{\infty}(pt)^{\frac{1}{2}}\,K_{\mu}\,(pt)\,t^{\rho}\,f\,(t^{-n/s})\,dt \tag{5.3}$$

Substituting the value of $f(t)$ from (5.2) in (5.3), interchanging the order of integration and evaluating the t-integral by (2.3), we arrive at the result.

Corollary: —For $n=s=1$, (5.1) reduces to a theorem given by Verma [(6), *p.* 99] in a slightly different form.

6. *Theorem 4:*—If $t^{\rho}\,f\,(t^{n/s})$ and $S_{v}\,\{f;z\}$ belong to $L\,(0,\,\infty)$,

$R\,(p)>0,\;-\tfrac{1}{2}<R\,(v)<\tfrac{1}{2},\;R\,(s\rho\pm s\mu\pm nv+n/2+3s/2)>0,$

then

$$K_{\mu}\left\{t^{\rho}\,f\,(t^{n/s});\,p\right\}=C.\int_{0}^{\infty}z^{\frac{1}{2}}\,S_{v}\,\{f;z\}\times$$

$$G^{2n,\,2s}_{3s,\,2n+s}\left[\left(\frac{p}{2n}\right)^{2n}\left(\frac{2s}{z}\right)^{2s}\;\middle|\;\begin{array}{l}\Delta\left(s;1\pm v/2\right),\;\Delta\left(s;3/2+v/2\right)\\[4pt]\Delta\left(n;\dfrac{3+2\rho+n/s\pm2\mu}{4}\right),\;\Delta\left(s;3/2+v/2\right)\end{array}\right]dz$$

Proof:—Proof of this theorem is exactly similar to that for theorem 3. Instead of (2.3), we shall use (2.4).

7. *Theorem 5:*—If $t^{\rho}\,f\,(t^{n/s})$ and $T_{v}\,\{f;z\}$ belong to $L\,(0,\,\infty)$,

$R\,(p)>0,\;-\tfrac{1}{2}<R\,(v)<\tfrac{1}{2},\;R\,(s\rho\pm s\mu+nv+3n/2+3s/2)>0,$

then

$$K_{\mu}\left\{t^{\rho}\,f\,(t^{n/s});\,p\right\}=C.\int_{\infty}^{0}z^{\frac{1}{2}}\,T_{v}\,\{f;z\}\times$$

$$G^{s+2n,\,s}_{3s,\,s+2n} \left[\left(\frac{p}{2n}\right)^{2n} \left(\frac{2s}{z}\right)^{2s} \Bigg| \begin{array}{c} \triangle \ (s;\ \tfrac{1}{2}-\nu/2),\ \triangle \ (s;\ 1\pm\nu/2) \\ \triangle \left(n;\ \dfrac{3+2\rho+n/s\pm2\mu}{4} \right),\ \triangle \ (s;\ \tfrac{1}{2}-\nu/2) \end{array} \right] dz$$

$$(7\cdot1)$$

Proof:—We have

$$f(t) = \int_0^\infty (tz)^{\frac{1}{2}} \ H_\nu \ (tz) \ T_\nu \ \{f;\ z\} \ dz \tag{7·2}$$

and

$$K_\nu \left\{ t^\rho f(t^{n/s});\ p \right\} = \int_0^\infty (pt)^{\frac{1}{2}} \ K_\mu \ (pt) \ t^\rho f \ (t^{n/s}) \ dt \tag{7·3}$$

Substituting the value of $f(t)$ from (7.2) in (7.3), interchanging the order of integration and evaluating the t-integral by (2.6), we arrive at the result.

Corollary:—For $n=s=1$, (7·1) reduces to a result recently given by Verma [(7), *p.* 270].

8. *Theorem 6:*—If $t^\rho f(t^{-n/s})$ and $T_\nu \ \{f;\ z\}$ belong to L (o, ∞),

$R \ (p) > o,\ -\tfrac{1}{2} < R \ (\nu) < \tfrac{1}{2},\ R \ (s\rho\pm s\mu-2n+3s/2) > o,$

then

$$K_\mu \left\{ t^\rho f(t^{-n/s});\ p \right\} = B. \int_0^\infty z^{\frac{1}{2}} \ T_\nu \ \{f;\ z\} \ \times$$

$$G^{s+2n,\,s}_{s,\,3s+2n} \left[\left(\frac{z}{2s}\right)^{2s} \left(\frac{p}{2n}\right)^{2n} \begin{array}{c} \triangle (s;\ \tfrac{1}{2}+\nu/2) \\ \triangle \left(n;\ \dfrac{3+2\rho-n/s\pm2\mu}{4} \right) \end{array} \right.$$

$$\triangle \ (s;\ \tfrac{1}{2}+\nu/2),\ \triangle \ (s;\ \pm\ \nu/2)] \ dz$$

Proof:—Proof of this theorem is exactly similar to that of theorem 5. Instead of (2·6) we shall use (2·5). here

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INFLUENCE OF LIGHT INTENSITY, PHOSPHATES AND POTASSIUM CHLORIDE ON NITRIFICATION AND NITROGEN LOSS BY THE ADDITION OF NITROGENOUS COMPOUNDS TO MUNICIPAL WASTE

By

N. R. DHAR *and* G. SINGH

Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad

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ABSTRACT

Experimental results show that when small amounts of ammonium sulphate or ammonium nitrate are added to municipal waste in composting, there is appreciable fixation of atmospheric nitrogen, the fixation of nitrogen is greater in light than in the dark.

When the amounts of the fertilizer added is increased, there is loss of nitrogen from the system, the loss is greater in light than in the dark.

Addition of different phosphates and potassium chloride markedly decreases this loss of nitrogen due to the conversion of a part of the unstable substance, ammonium nitrite formed in nitrification of all nitrogenous materials, to nitrites of sodium, potassium and calcium, which are more stable than ammonium nitrite.

Nitrogen being an elusive substance the nitrogen fixed or added as manure does not remain for a long time in the soil under ordinary circumstances. The researches of Lipman and Blair (1), Russell and Richards (2), Shutt and others (3) show that nitrogen in the gaseous stage is lost from soils when the conditions are favourable for oxidation. The loss of nitrogen in this process may be greater than double the amount of nitrogen taken up by the plant grown on the soil. Nearly 70% of the added nitrogen is said to have been lost when wheat plots in Rothamsted, England, have received annually 14 tons of farm yard manure containing 200 lbs nitrogen per acre.

When any nitrogenous substance either organic or ammonium salt is added to the soil and the conditions are favourable for oxidation as in ploughing, the nitrogenous compounds undergo oxidation and form ammonia, nitrite and finally nitrate. As an intermediate state, there is always the possiblity of the formation of ammonium nitrite in this process. It is well known that ammonium nitrite is very unstable and undergoes decomposition into nitrogen and water.

It has also been observed that the addition of carbonaceous substances tends to preserve the soil or added nitrogen. Viswanath (4) obtained greater loss of

nitrogen and greater velocity of oxidation in the nitrification of ammonium salts than with F. Y. M. or green manures. Phosphates have been found by us to preserve nitrogen from being lost due to the formation of stable phospho-proteins. When potassium chloride is added to organic matter in composts, potassium nitrite, which is more stable than ammonium nitrite, is formed and hence nitrogen loss decreases in presence of potassium chloride.

The following experiments were performed to throw more light on the mechanism of nitrification and nitrogen loss from ammonium sulphate and ammonium nitrate when mixed with municipal waste. An attempt has also been made to investigate the influence of light, phosphates, potassium chloride and organic matter (in the form of municipal waste) on nitrification and losses of nitrogen.

EXPERIMENTAL

In the first set 90% of nitrogen was taken as municipal waste and 10% nitrogen was taken from different nitrogenous compounds like ammonium sulphate and ammonium nitrate of the total nitrogen content of municipal waste. In these cases 90 gms of finely powdered municipal waste was taken in ten clean 250 c. c. beakers and, weighed amount of ammonium sulphate and ammonium nitrate, i e., 0·2544 gm and 0·1515 gm respectively (each containing 0·05242 gm of N_2) were added to each beaker containing 0·4713 gm or N_2 as municipal waste. While another set containing 50% of the total nitrogen of municipal waste and 50% nitrogen from different nitrogenous fertilizers were taken in each beaker.

For investigating the effect of phosphates and potassium chloride on the phenomenon of photo-chemical nitrification and nitrogen loss, phosphates (superphosphate and Tata basic slag) to the extent of $0·5\%$, P_2O_5 alone and in conjunction with $0·5\%$ potassium chloride, were added to the beakers which contained 90% nitrogen and 50% nitrogen from municipal waste, and 10% nitrogen and 50% N_2 from the above mentioned nittogenous fertilizers. Thus, two identical sets were prepared. The contents of the beakers were thoroughly mixed with a glass rod in order to make them uniform and then covered with their beaker covers. 50% distilled water was added to each beaker and the material was again mixed well. One of the two sets was exposed to the light of a 100 Watt bulb while the others were kept beside it covered with a thick black cloth in order to cut off the light. In order to facilitate the oxidation of the carbonaceous compounds in the beakers, the mixtures were stirred daily and 15% distilled water was added.

From time to time a composite sample of each mixture was taken out and was analysed for their total carbon, total nitrogen, ammoniacal nitrogen and nitrate nitrogen. The experimental results are recorded in the following pages.

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TABLE 1

Analysis of nitrogenous compounds.

Ammonium sulphate ... 20·6% nitrogen

Ammonium nitrate ... 34·6% nitrogen

Analysis of Municipal Waste

Moisture	...	35·6%
Loss on ignition	...	29·62%
Ash	...	70·36%
HCl insoluble	...	57·24%
R_2O_3	...	9·76%
Fe_2O_3	...	3·12%
CaO	...	1·623%
P_2O_5	...	0·8234%
K_2O	...	0·7132%
Total carbon	...	2·54%
Total nitrogen	...	0 5242%
$NH_3 - N$	...	0·0137 %
$NO_3 - N$	...	0·0214%
pH (1:5)	...	8·1
C/N ratio	...	24·1

Analysis of superphosphate and Tata basic slag

		Super phosphate	Tata basic slag
Silica	...	44·82	33·56
Sesquioxide	...	—	—
Fe_2O_3	...	—	17·79
Al_2O_3	...	—	—
Total P_2O_5	...	16·52	7·57
Av. P_2O_5	...	14·12	4·21
Total CaO	...	36·18	34·52
Total L_2O	...	0·24	—
Total Mg()	...	0·26	5·25

TABLE 2

100 gms Municipal waste + 50% moisture

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total N %	C/N ratio
			LIGHT			
0	12·54	0·5242	0·0137	0·0214	—	24·1
30	9·97	0·5781	0·0197	0·03344	10·3	17·4
60	8·76	0·6059	0·0236	0·442	15·6	14·6
90	8·20	0·6321	0·02634	0·05203	20·6	13·0
			DARK			
0	12·54	0·5242	0·0137	0·0214	—	24·1
30	10·59	0·5579	0·0160	0·0257	7·2	19·2
60	9·62	0·5755	0·0184	0·0333	9·8	16·8
90	8·98	0·5986	0·0207	0·0415	14·2	15·2

TABLE 3

90 gms M. W. + 0·2544 gm of $(NH_4)_2SO_4$ (0·05242 gm of N_2)

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total N %	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	9·34	0·5692	0·0667	0·0225	8·6	15·6
60	8·21	0·5965	0·0682	0·0234	13·8	13·9
90	7·54	0·6164	0·0706	0·0237	17·6	12·3
			DARK			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	9·98	0·5514	0·0647	0·0194	5·2	18·1
60	9·00	0·5682	0·0689	0·0211	8·4	16·0
90	8·51	0·5855	0·0708	0·0213	11·7	14·6

TABLE 4

90 gms M. W. + 0·2544 gm of $(NH_4)_2SO_4$ (0.05242 gm of N_2) + 0·5% P_2O_5 as super phosphate

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total N%	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	8·51	0·5939	0·0670	0·0240	13·3	14·4
60	7·15	0·6426	0·0693	0·0252	22·6	11·1
90	6·48	0·6620	0·0711	0·0256	26·3	9·8
			DARK			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	8·88	0·5729	0·0686	0·0200	9·3	15·5
60	8·53	0·5926	0·0705	0·0215	14·2	14·4
90	7·54	0·6148	0·0717	0·0228	17·3	12·3

TABLE 5

90 gms M. W. + 0·2544 gm of $(NH_4)_2SO_4$ (0·05242 gm of N_2) + 0·5% P_2O_5 as superphosphate + 0·5% K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total N%	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	8·44	0·6064	0·0675	0·0243	15·7	14·0
60	7·17	0·6562	0·0700	0·0268	25·2	11·0
90	6·31	0·6825	0·0719	0·0285	30·2	9·2
			DARK			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	8·80	0·5829	0·0690	0·0206	11·2	15·1
60	7·82	0·6217	0·0710	0·0230	18·6	12·6
90	7·33	0·6363	0·0724	0·0240	21·4	11·6

TABLE 6

90 gms M. W. + 0·2544 gm of $(NH_4)_2SO_4$ (0·05242 gm of N_2) + 0·5°/₀ P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Avilable N increase over total N°/₀	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0647	0 0192	—	21·6
30	8·22	0·6101	0·0674	0·0251	16·4	13·4
60	6·99	0·6631	0·0700	0·0266	26·5	10·5
90	6·24	0·6840	0·0716	0·0268	30·5	9·1
			DARK			
0	11·28	0·5242	0·0647	0·0192	—	21·6
30	8·62	0·5892	0·0690	0·0213	12·4	14·8
60	8·21	0·6217	0·0710	0·0226	18·6	12 9
90	7·25	0·6384	0·0723	0·0236	21·8	11·5

TABLE 7

90 gms M. W. + 0·2544 gm of $(NH_4)_2SO_4$ (0·05242 gm of N_2) + 0·5°/₀ P_2O_5 as T. B. S. + 0·5°/₀ K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Avilable N increase over total N°/₀	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0647	0·0192	—	2 1·6
30	7·99	0·6222	0·0681	0·0256	18·7	12·8
60	6·75	0·6777	0·0710	0·0273	29·3	10·0
90	5·99	0·7055	0·0725	0·0296	34·5	8·5
			DARK			
0	11·28	0·5242	0·0647	0 0192	—	21·6
30	8·44	0·5991	0·0700	0·0210	14·3	14·3
60	7·66	0·6416	0·0721	0·0238	22·4	11·9
90	6·94	0·6583	0·0732	0·0248	25·6	10·6

TABLE 8

90 gms of M. W. + 0·1515 gm of NH_4NO_3 (0·05242 gm of N_2)

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Avilable N increase over total nitrogen %	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	9·24	0·5886	0·0271	0·0639	12·3	15·9
60	8·19	0·6311	0·0296	0·0646	20·4	13·0
90	7·38	0·6458	0 0317	0·0652	23·2	11·6
			DARK			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	9·54	0·5729	0·0281	0·0602	9·3	16·7
60	8·84	0·5902	0·0805	0·0615	12·6	14·9
90	8·32	0·6007	0·0320	0·0617	14·6	13·8

TABLE 9

90 gms M. W. + 0·1515 gm of NH_4NO_3 (0·05242 gm of N_2) + 0·5% P_2O_5 as superphosphate

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Avilable N increase over total nitrogen %	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·32	0·6175	0·0283	0·0642	17·8	13·6
60	6·99	0·6667	0·0315	0·0655	27·2	10·4
90	5·96	0·6950	0·0316	0·0680	32 6	8·6
			DARK			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·77	0·5933	0·0291	0·0612	13·2	14·8
60	7·99	0·6222	0·0318	0·0615	18·7	12·8
90	7·51	0·6358	0·0325	0 0634	21·3	11·9

TABLE 10

90 gms M. W. + 0·1515 gm of NH_4NO_3 (0·05242 gm of N_2) + 0·5% P_2O_5 as Superphosphate + 0·5% K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen %	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·22	0·6269	0·0297	0·0646	19·6	13·2
60	6·85	0·6867	0·0320	0·0662	31·0	10·0
90	5·82	0·7150	0·0331	0·0704	36·4	8·1
			DARK			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·62	0·6101	0·0304	0·0615	16·4	14·1
60	7·82	0·6437	0·0330	0·0627	22·8	12·2
90	7·31	0·6562	0·0341	0·0646	25·2	11·2

TABLE 11

90 gms of M. W. + 0·1515 gm of NH_4NO_3 (0·05242 gm of N_2) + 0·5% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen %	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·11	0·6321	0·0284	0·0661	20·6	12·8
60	6·63	0·6840	0·0320	0·0667	30·5	9·7
90	5·69	0·7108	0·0324	0·0686	35·8	8·0
			DARK			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·54	0·6091	0·0302	0·0615	16·2	14·2
60	7·71	0·6369	0·0321	0·0631	21·5	12·2
90	7·31	0·6531	0·0330	0·0648	24·6	11·2

TABLE 12

90 gms of M. W. + 0·1515 gm of NH_4NO_3 (0·05242 gm of N_2) + 0·5°/o P_2O_5 as Tata basic slag + 0·5°/o K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen %	C/N ratio
			LIGHT			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	7·87	0·6468	0·0304	0·0655	23·4	12·2
60	6·48	0·7055	0·0331	0·0687	34·6	9·2
90	5·44	0·7375	0·0340	0·0711	40·7	7·4
			DARK			
0	11·28	0·5242	0·0241	0·0598	—	21·6
30	8·44	0·6295	0·0315	0·0620	20·1	13·6
60	7·59	0·6589	0·0330	0·0646	25·7	11·6
90	7·05	0·6730	0·0342	0·0658	28·4	10·5

TABLE 13

50 gms of M. W. + 1·2723 gms of $(NH_4)_2SO_4$ (0·2621 gm of N_2)

			LIGHT			
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	5·24	0·4425	0·1852	0·0424	—15·6	11·9
60	4·82	0·4168	0·1642	0·0478	—20·5	11·7
90	4·29	0·4005	0·1475	0·0544	—23·6	10·7
			DARK			
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	5·52	0·4572	0·2043	0·0362	—12·8	12·2
60	5·11	0·4370	0·1873	0·0392	—16·6	11·8
90	4·81	0·4273	0·1758	0·0418	—18·5	11·4

TABLE 14

50 gms of M. W. + 1·2723 gms of $(NH_4)_2SO_4$ (0·2621) gm of N_2) + 0·5°/$_0$ P_2O_5
as superphosphate

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen %	C/N ratio
			LIGHT			
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	4·85	0·4645	0·1906	0·0499	—11·4	10·5
60	4·12	0·4367	0·1726	0·0514	—15·7	9·5
90	3·72	0·4220	0·1583	0·0565	—19·5	8·8
			DARK			
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	5·11	0·4797	0·2108	0·0408	— 8·5	10·8
60	4·49	0·4577	0·1953	0·0416	—12·7	9·9
90	4·23	0·4493	0·1843	0·0465	—14·3	9·5

TABLE 15

50 gms of M. W. + 1·2723 gms of $(NH_4)_2SO_4$ (0·2621 gm of N_2) + 0·5% P_2O_5
as superphosphate + 0·5% K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen %	C/N ratio
			LIGHT			
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	4·76	0·4692	0·1932	0·0532	—10·5	10·2
60	4·07	0·4477	0·1787	0·0551	—14·6	9·2
90	3·62	0·4336	0·1665	0·0572	—17·3	8·4
			DARK			
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	5·00	0·4750	0·2147	0·0417	— 7·4	10·6
60	4·42	.0·4690	0·2016	0·0439	—10·5	9·6
90	4·12	0·4603	0·1906	0·0496	— 12·2	8·9

TABLE 16

50 gms of M. W. $+$ 1·2723 gms of $(NH_4)_2SO_4$ (0·2621 gm of N_2) $+$ 0·5°/₀ P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen°/₀	C/N ratio
LIGHT						
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	4·72	0·4813	0·1916	0·0534	—8·2	9·8
60	4·01	0·4577	0·1732	0·0555	—12·7	8·9
90	3·60	0·4388	0·1604	0·0594	—16·3	8·3
DARK						
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	5·29	0·4891	0·2132	0·0424	—6·7	11·0
60	4·39	0·4797	0·1982	0·0445	—8·5	9·3
90	4·13	0·4582	0·1882	0·0479	—12·6	9·1

TABLE 17

50 gms of M. W. $+$ 1·2723 gm of $(NH_4)_2SO_4$ (0·2621 gm of N_2) $+$ 0·5°/₀ P_2O_5 as Tata basic slag $+$ 0·5°/₀ K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_3 - N$ (gms)	$NO_3 - N$ (gms)	Available N increase over total nitrogen°/₀	C/N ratio
LIGHT						
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	4·60	0·4844	0·1951	0·0571	7·6	9·5
60	3·90	0·4687	0·1801	0·0584	10·6	8·4
90	3·34	0·4477	0·1681	0·0607	14·6	7·5
DARK						
0	6·27	0·5242	0·2689	0·0107	—	12·0
30	5·17	0·4970	0·2162	0·0433	5·2	10·5
60	4·30	0·4870	0·2048	0·0452	7·1	8·9
90	3·99	0·4703	0·1934	0·0507	10·3	8·4

TABLE 18

50 gms of M. W. + 0·7575 gm of KH₄NO₃ (0·2621 gm of N₂)

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	HN₃ — N	NO₃—N	Available N increase over total nitrogen%	C/N ratio
			LIGHT			
0	6·27	0·5242	0·0657	0·2133	—	12·0
30	5·18	0·4634	0·0253	0·2146	11·6	11·2
60	4·68	0·4420	0·0109	0·2153	15·7	10·6
90	4·20	0·4273	0·0011	0·2156	18·5	9·9
			DARK			
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	5·37	0·4807	0·0352	0·2142	8·3	11·1
60	5·05	0·4629	0·0259	0·2147	11·7	10·9
90	4·76	0·4524	0·0179	0·2150	13·7	10·5

TABLE 19

50 gms of M. W. + 0·7575 gm of NH₄NO₃ (0·2621 gm of N₂) + 0·5% P₂O₅ as superphosphate

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	HN₃ — N	NO₃—N	Available N increase over total nitrogen%	C/N ratio
			LIGHT			
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	4·73	0·4729	0·0325	0·2152	9·8	10·0
60	4·00	0·4580	0·0214	0·2162	12·6	8·8
90	3·43	0·4446	0·0117	0·2167	15·2	7·7
			DARK			
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	4·82	0·4907	0·0432	0·2148	6·4	10·0
60	4·61	0·4792	0·0354	0·2156	8·6	9·8
90	4·26	0·4690	0·0280	0·2161	10·5	9·2

TABLE 20

50 gms of M. W. + 0·7575 gm of NH_4NO_3 (0·2621 gm of $_2$) + 0·5% P_2O_5 as superphosphate + 0·5% K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	NH_3—N (gms)	NO_3—N (gms)	Available N increase over total nitrogen %	C/N ratio
		LIGHT				
0	6·27	0·5242	0·0667	0·2138	—	12·0
30	4·64	0·4797	0·0357	0·2167	8·5	9·8
60	3·92	0·4655	0·0274	0·2175	11·2	8·5
90	3·32	0·4545	0·0171	0·2183	13·3	7·3
		DARK				
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	4·86	0·4938	0·0457	0·2154	5·8	9·9
60	4·49	0·4855	0·0393	0·2162	7·4	9·3
90	4·18	0·4807	0·0345	0·2168	8·3	8·7

TABLE 21

50 gms of M. W. + 0·7575 gm of NH_4NO_3 (0·2621 gm of N_2) + 0·5% P_2O_5 as Tata basic slag

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	NH_3—N (gms)	NO_3—N (gms)	Available N increase over total nitrogen %	C/N ratio
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	4·61	0·4849	0·0369	0·2167	7·5	9·6
60	3·86	0·4687	0·0227	0·2174	10·6	8·3
90	3·27	0·4498	0·0144	0·2182	14·2	7·4
		DARK				
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	4·85	0·4996	0·0456	0·2158	4·7	9·8
60	4·51	0·4891	0·0386	0·2164	6·7	9·3
90	4·17	0·4792	0·0325	0·2169	8·6	8·8

TABLE 22

50 gms of M. W. + 0·7575 gm of NH_4NO_3 (0·2621 gm of N_2) + 0·5% P_2O_5 as
Tata basic slag + 0·5% K as KCl

Period of exposure in days	Total carbon (gms)	Total nitrogen (gms)	$NH_2 - N$ (gms)	$NO_2 - N$ (gms)	Avilable N increase over total nitrogen %	C/N ratio
LIGHT						
0	6·27	0·5242	0·0657	0·2138	—	12·0
30	4·48	0·4917	0·0407	0·2176	6·2	9·1
60	3·79	0·4786	0·0287	0·2184	8·7	8·0
90	3·11	0·4640	0·0199	0·2191	11·5	6·7
DARK						
0	6·27	0·5242	0·0657	0·2138	...	12·0
30	4·80	0·5028	0·0471	0·1263	4·1	9·6
60	4·35	0·4949	0·0416	0·2173	5·6	·8·8
90	4·03	0·4891	0·0366	0·2181	6·7	8·3

DISCUSSION

The foregoing experimental results show that when small amounts of nitro·genous fertilizers like ammonium sulphate and ammonium nitrate are added to the municipal waste, there is appreciable fixation of atmospheric nitrogen. When 10% of the total nitrogen (0·5242%) content of municipal waste is added as nitrogen fertilizer, 17·6 to 40·7% nitrogen fixation is observed within a period of 90 days in light while in the case of the covered sets there is less fixation of atmospheric nitrogen from 11·7 to 28·4% within the same period. In every case it has been observed that there is more nitrogen fixation in light than in the dark. The maximum fixation of nitrogen was observed with ammonium nitrate, 40·7% in light and 28·4% in the dark, whereas the minimum nitrogen increase was observed with ammonium sulphate, 17·6% in the light and 11·7% in the dark.

It seems that there is a marked influence of light on the fixation of nitrogen and light energy is also utilised in fixing atmospheric nitrogen in municipal waste. This remarkable influence of light intensities on nitrogen fixation will be clear from the following considerations.

It has been shown by a number of workers (5,6,7) that in soils the process of nitrogen fixation is opposed by ammonification and denitrification. Thus, on one hand the nitrogen, fixed on the surface of municipal waste or soil, undergoes various

changes aided by light absorption to form amino-acids and proteins and then these amino-acids and proteins formed in the soil undergo ammonification and nitrification, which are also accelerated by light absorption and form nitrites and nitrates as in the following scheme :—

$$\text{Proteins} \rightarrow \text{Amino-acids} \xrightarrow{+O_2} \text{NH}_4 \text{ compounds} \xrightarrow{+O_2} NO_2 \xrightarrow{+O_2} NO_3$$
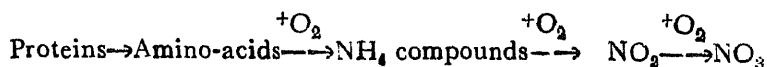
In these series of reactions the unstable substance ammonium nitrite, is formed which decomposes readily liberating energy and nitrogen gas as in the following equation :—

$$NH_4NO_2 = N_2 + 2H_2O + 718 \text{ K. Cals.}$$
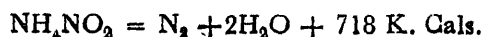
There is greater fixation of atmospheric nitrogen in the presence of large amounts of carbonaceous materials in municipal waste, which seems to check the loss of nitrogen by the fixation of atmospheric nitrogen due to energy evolved in the slow oxidation of cellulose, lignin and other carboydrates present in municipal waste. Secondly only 10'/ of the total nitrogen content of municipal waste was added from different fertilizers.

As soon as phosphates are added, the nitrogen content of the system is increased. It seems that phosphate play a vital role in the improvement and maintenance of the nitrogen status of municipal waste. The proteins that are present in the municipal waste humus or those formed due to fixation of atmospheric nitrogen are likely to be stabilised by the formation of phospho-proteins in the combination of proteins and phosphate. Moreover, these phosphates and municipal wastes contain Ca^{++}, K^+, Na^+ and Mg^{++} ions. In the presence of these ions, instead of the unstable ammonium nitrite, are produced calcium nitrite, potassium nitrite sodium nitrite etc. In comparison to ammonium nitrite, calcium and potassium and sodium compounds are more stable, and, thus nitrogen conservation is observed. It has also been observed in our experiments that when potassium chloride along with the phosphate is added, there is more fixation of atmospheric nitrogen.

From the second set of the foregoing results it is observed that there is always a greater loss of nitrogen from municipal waste in the sets exposed to light, i.e., 11·5°/$_0$ to 23·6°/$_0$ than in those kept covered with a thick black cloth, i.e., 6·7°/$_0$ to 18·5°/$_0$ of nitrogen is lost. It is clear that nitrification of these salts is much quicker in exposed beakers than those which were kept covered.

The possible explanation for this nitrogen loss may be that at the first stage during the nitrification taking place in the soil, ammonium ions and nitrite ions are present simultaneously which combine to give ammonium nitrite, which, being unstable, decomposes into free nitrogen and water. Thus, gaseous nitrogen escapes in air from the field of the experiment, causing the loss, thus :—

$$NH_4NO_2 = N_2 + 2H_2O + 718 \text{ K. Cals.}$$
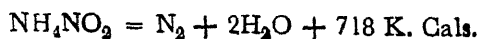
This view of the nitrification, first advanced by Dhar, has been confirmed and supported by various workers in different parts of the world.

The checking loss of nitrogen by phosphates can be explained in various ways. Firstly, they may from phospho-proteins and phosphorylated compounds with nitro-

genous substances present in the humus which resist ammonification, nitrification and loss of nitrogen, as has already been already explained.

Secondly, the effect of Ca^{++}, K^+, Na^+ and Mg^{++} has already been explained in the previous lines as these cations form $Ca(NO_3)_2$, KNO_2 and $NaNO_2$ which are more stable than ammonium nitrite. This also explains the presence of greater amounts of NO_3 in the systems because calcium nitrite has better chances of getting oxidised to nitrate than ammonium nitrite, as quite a good amount of Ca^{++} ions is found in municipal waste.

Also, it is well known that in the presence of H ions the decomposition of ammonium nitrite is greatly accelerated. But, as the acids, nitrous and nitric-produced during the nitrification of nitrogenous compounds, are utilised in increasing the availability of the sparingly soluble phosphate like rock phosphates and Tata or Kulti basic slag, little or no hydrogen ion is left to produce acidity in the system. Moreover, phosphates themselves act as buffers and do not allow the soil reaction to change to the acidic side. These view explain clearly the marked checking of the nitrogen loss with superphosphate and Tata basic slag.

It is also interesting to record here that due to the presence of large amounts of carbonaceous compounds in the municipal waste, the loss of nitrogen is markedly checked because carbohydrates retard nitrification and nitrogen loss. The greater the amount of carbonaceous substances, the greater the retarding effect on nitrification and the loss of nitrogen.

Dhar and Mukherji (8) have explained the checking of the loss from the point of view of negative catalytic effect of carbohydrates present in the plant materials on the nitrification of ammonium sulphate, which is an oxidation reaction.

Dhar and coworkers have stated : "Both carbohydrates and facts markedly act as negative catalysis and retard oxidation of the amino-acids and proteins and are likely to act as protein sparers in the animal body. Similarly, the oxidation of carbohydrates and fats is also retarded by proteins and amino-acids in the soil". These results have been confirmed by several workers.

It is, therefore, clear from the above results that the value of artificial fertilizers should be greatly enhanced if they are mixed with carbonaceous substances like municipal waste or other waste organic meterials rainforced with various phosphates and potassium salts.

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INFLUENCE OF LIGHT AND PHOSPHATES ON NITROGEN TRANSFORMATIONS DURING THE COMPOSTING OF CANE TRASH AND OTHER ORGANIC SUBSTANCES

By

N. R. DHAR *and* G. SINGH

Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad

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ABSTRACT

In the composting of cane trash grass, dry leaves and other agriculture wastes with and without the addition of Bihar rock phosphate, Tata basic slag, Belgian basic slag, Superphosphate or Algerian rock phosphate and exposed to light or kept in the dark, the total and available nitrogen of the system are always greater in the phosphated and illuminated systems than in the unphosphated and the covered sets. Hence a mixture of organic matter and different calcium phosphates including Indian basic slags is very helpful in increasing land fertility especially in presence of light and supply of all important plant nutrients in increased crop production.

The preparation of composts probably originated in China (King, 1926). The Chinese and the Japanese farmers still depend to a great extent on the home-produced manure. The first important advancement in the practice of composts was effected by Howard (1) 30 years ago in India, where, in collaboration with Jackson and Wad (2) and other workers, they systematised the traditional procedure into a composting method known as the Indore method because of the locality in which it was developed.

Dhar, in his presidential address to the National Academy of Sciences (India), 1952, has stated as follows:

"From our composting experiments we are convinced that calcium phosphate is helpful in composting of plant materials, specially in the absence of nitrogenous fertilizers because phosphates help in nitrogen fixation by organic matter and, hence, calcium phosphate or phosphate rock should be largely used in composting".

We have taken up the present investigtion to study systematically the effect of phosphates in the presence and absence of artificial or solar light on nitrogen transformations and availability of phosphate during the composting of cane trash and other organic substances in buckets and pits.

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1. Experiments with cane trash in buckets.

The cane trash was well dried, chaffed and powdered by an electric grinder. A weighed amount of powdered cane trash was placed in buckets and to it was applied a dose of 0·25% P_2O_5 from different sources of phosphatic materials in different buckets.

The reacting mass was mixed well by a glass rod and was kept at a moisture level of 30% throughout the period of the experiment. To facilitate decomposition, the whole mass of each bucket was stirred well thrice per week and the temperature was recorded daily at noon—one set was exposed to the light of a 100 Watt electric bulb while the corresponding set was kept covered with a thick black cloth. After definite intervals, a portion of the mass was taken out of each bucket, powdered, sieved and analysed for total carbon, total nitrogen, ammoniacal nitrogen, nitric nitrogen, available phosphate etc.

2. Experiment with a mixture of grass, dry leaves and vegetable waste.

These experiments were conducted in pits. Each pit, with a cross section of seven feet square bottom, one foot depth and eight feet square top, was charged by spreading alternate layers of the well mixed organic matter followed by phosphatic fertilizers. This type of slanting construction of the pits provided a simple way to discourage insects, rodents and filled the pits to their maximum capacity. The total amount of the phosphate required to maintain 0·5% P_2O_5 was added in powdered form from different sources of phosphatic fertilizers. The contents of the pits were kept at a moisture level of 60% by adding water at intervals. The contents of the pits were turned down from time to time for aeration and decomposition.

Out of the eight pits constructed, four were exposed to sunlight and the remaining were kept covered by wooden planks. The temperature of each compost pit from fifteen places in the pit was recorded daily at 2 P.M. by inserting the mercury bulb of the thermometer at a depth of 6 inches.

After certain intervals, well rotten mass was taken out of different layers of the compost pit in small amounts and also from different spots. After mixing it thoroughly it was kept in an oven for complete drying at 105°C for 5-6 hours. The mass was then powdered and sieved through a 60 mesh sieve. It was then analysed for total carbon, total nitrogen, ammoniacal nitrogen, nitric nitrogen, and for available P_2O_5.

TABLE 1

Analysis of cane trash and organic materials

	Cane trash %	Organic materials (mixture of dry leaves and grasses %
Loss on ignition	73·23	74·26
Ash	26·76	25·74
HCl insoluble	17·23	17·38
Sesquioxide	3·1244	3·5233
Iron oxide	2·3213	1·3105
P_2O_5	0·5459	0·5142
K_2O	1·6021	1·2335
C_aO	3·2418	2·3415
MgO	0·1043	0·1541
Total carbon	32·70	42·33
Total nitrogen	0·6615	0·7926
pH (1:5)	8·3	8 2
Conductivity	$1·4 \times 10^{-3}$ (Mhos/cm)	$1·3 \times 10^{-3}$ (Mohs/cm)
C/N ratio	49·5	53·5

TABLE 2

	Bihar rock phosphate %	Tata basic slag %	Belgian basic slag %	Super- phosphate %	Algerian rock phos- phate "C" %
Silica	25·62	33 56	33·26	44·82	51·76
Sesquioxide	30·12	—	14·45	—	—
Fe_2O_3	3·82	17·79	5·12	—	—
Al_2O_3	26·30	—	—	—	—
Total P_2O_5	27·83	7·57	17·82	16·52	24·14
Av. P_2O_5	1·17	4·21	6·16	14·12	6·63
Total CaO	14·93	34·52	27·44	36·18	10·56
Total K_2O	—	—	0·72	0·24	9·56
Total MgO	0·52	5·25	2·00	0·26	2·18

TABLE 3

2 Kgms cane trash + 30% moisture

Period of exposure in days	Total carbon %	Total nitrogen %	NH$_3$—N %	NO$_3$—N %	Total available N over total N %	pH	Conductivity × 10^{-3} (Mhos/cm)	C/N ratio
			LIGHT					
0	32·70	0·6615	—	—	—	8·3	1·4	49·5
45	21·95	0·8374	0·02688	0·04177	8·2	7·4	1·9	26·3
90	19·43	0·9042	0·03175	0·06951	11·2	7·2	2·4	21·5
120	17·83	0·9366	0·03722	0·07934	12·5	7·0	2·5	19·1
150	17·27	0·8111	0·02587	0·04875	9·2	7·6	2·0	21·3
			DARK					
0	32·70	0·6615	—	—	—	8·3	1·4	49·5
45	24·69	0·7957	0·02203	0·03207	6·8	7·6	1·7	31·5
90	23·12	0·8506	0·02408	0·05417	9·2	7·4	1·9	27·2
120	21·69	0·8824	0·03158	0·06018	10·1	7·3	2·0	24·6
150	21·16	0·7916	0·02192	0·04378	8·3	7·4	1·6	26·7

TABLE 4

2 Kgms cane trash + 0·25% P$_2$O$_5$ as Algerian rock phosphate "C"

Period of exposure in days	Total carbon %	Total nitrogen %	NH$_3$—N %	NO$_3$—N %	Total available N over total N %	pH	Conductivity × 10^{-3} (Mhos/cm)	C/N ratio
			LIGHT					
0	32·36	0·6546	—	—	—	8·3	1·4	49·7
45	18·61	1·2817	0·07691	0·14482	17·3	6·8	2·7	14·5
90	15·34	1·3759	0·09473	0·21346	22·4	6·7	3·5	11·1
120	14·31	1·2728	0·08327	0·17255	20·1	6·5	3·2	11·2
150	13·56	1·2425	0·7903	0·15207	18·6	7·7	3·0	10·9
			DARK					
0	32·36	0·6546	—	—	—	8·3	1·4	49·7
45	20·42	1·0028	0·04846	0·08792	13·6	7·1	7·1	20·4
90	18·26	1·0892	0·05790	0·12181	16·5	6·9	6·9	16·9
120	17·03	1·1147	0·06562	0·13725	18·2	18·2	6·7	15·3
150	16·12	1·0278	0·05736	0·12043	17·3	17·3	7·3	15·8

TABLE 5

2 Kgms cane trash + 0·25°/o P_2O_5 as Tata basic slag

Period of ex-posure in days	Total carbon °/o	Total Nitrogen °/o	NH_3-N °/o	NO_3-N °/o	Total availa-ble N over total N °/o	pH	Conduc-tivity × 10⁻³ (Mhos/ cm)	C/N ratio
				LIGHT				
0	31·50	0·6401	—	—	—	8·3	1·4	49·2
45	16·79	1·2590	0·08442	0·19885	22·5	7·5	3·2	13·4
90	13·74	1·4133	0·09918	0·25838	25·3	7·3	3·8	9·7
120	11·72	1·3102	0·09263	0·21526	23·5	7·1	3·6	8·9
150	10·84	1·2819	0·08628	C·19958	22·3	7·9	3·4	8·4
				DARK				
0	31·50	0·6401	—	—	—	8·3	1·4	49·2
45	18·65	1·0477	0·06243	0·11882	17·3	7·6	2·8	17·9
90	15·82	1·1368	0·07893	0·15184	20·3	7·4	3·4	14·0
120	14·40	1·0664	0·06676	0·13052	18·5	7·2	3·2	13·5
150	13·46	1·0539	0·06382	0·12166	17·6	7·5	3·0	12·8

TABLE 6

2 Kgms cane trash + 0·25% P_2O_5 as superphosphate

Period of ex-posure in days	Total carbon °/o	Total Nitrogen °/o	NH_3-N °/o	NO_3-N °/o	Total availa-ble N over total N °/o	pH	Conduc-tivity × 10⁻³ (Mhos/ cm)	C/N ratio
				LIGHT				
0	32·21	0·6516	—	—	—	8·3	1·4	49·5
45	19·30	1·2771	0·07265	0·15750	18·1	6·3	2·7	15·1
90	15·95	1·4055	0·09662	0·23226	23·4	6·0	·3·4	11·3
120	15·01	1·2931	0·09381	0·18162	21·3	5·9	3·2	11·6
150	13 44	1·2622	0·08573	0·16544	19·9	6·7	3·0	10·6
				DARK				
0	32·21	0·6516	—	—	—	8·3	1·4	49·5
45	20·30	1·0112	0·05988	0·08977	14·8	6·6	2·4	20·0
90	18·00	1·1057	0·06881	0·13463	18·4	6·4	3·0	16·3
120	16·69	1·1409	0·07215	0·15031	19·5	6·1	3·1	12·0
150	15·72	1·0497	0·06355	0·13610	17·5	6·4	2·8	15·1

TABLE 7

Mixed organic material + 60% moisture

Period of ex-posure in days	Total carbon %	Total nitrogen %	$NH_3 - N$ %	$NO_3 - N$ %	Total available N over total N %	pH	Conductivity $\times 10^{-3}$ (Mhos/cm)	C/N ratio
LIGHT (Sunlight)								
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	27·39	0·9961	0·02890	0·04581	7·5	7·8	2·1	26·3
60	23·96	1·0668	0·03698	0·07396	10·4	7·5	2·6	22·6
90	20·28	1·1270	0·04967	0·11135	14·2	7·3	3·0	18·1
120	17·53	0·9850	0·03417	0·06235	9·8	7·8	2·8	17·8

Period of ex-posure in days	Total carbon %	Total nitrogen %	$NH_3 - N$ %	$NO_3 - N$ %	Total available N over total N %	pH	Conductivity $\times 10^{-3}$ (Mhos/cm)	C/N ratio
DARK								
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	32·68	0·8624	0·01267	0·02354	·4·2	8·0	1·9	38·0
60	30·19	0·9527	0·02518	0·04436	7·3	7·7	2·2	31·7
90	26·84	1·0272	0·03537	0·08275	11·5	7·5	2·4	26·8
120	24·77	0·9622	0·02409	0·04518	7·2	7·6	2·2	25·8

TABLE 8

Mixed organic material + 0·5% P_2O_5 as Bihar rock phosphate

Period of ex-posure in days	Total carbon %	Total nitrogen %	$NH_3 - N$ %	$NO_3 - N$ %	Total available N over total N %	pH	Conductivity $\times 10^{-3}$ (Mhos/cm)	C/N ratio
LIGHT (Sunlight)								
0	42·33	0·7925	—	—	—	8·2	1·2	53·5
30	25·11	1·3260	0·05660	0·09821	11·6	7·4	2·4	19·0
60	21·09	1·4203	0·06196	0·17392	15·2	7·1	2·6	14·8
90	17·40	1·4940	0·08563	0·18627	18·2	7·0	2·9	11·6
120	14·69	1·4322	0·06470	0·14440	14·6	7·7	2·7	10·2

Period of ex-posure in days	Total carbon %	Total nitrogen %	$NH_3 - N$ %	$NO_3 - N$ %	Total available N over total N %	pH	Conductivity $\times 10^{-3}$ (Mhos/cm)	C/N ratio
DARK								
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	30·65	1·1556	0·04059	0·06918	9·5	7·9	1·9	26·6
60	27·31	1·2158	0·10818	0·10818	13·1	7·6	2·3	22·5
90	24·22	1·2626	0·06365	0·13331	15·6	7·3	2·5	19·2
120	21·85	1·2110	0·04826	0·10553	12·7	7·5	2·3	18·0

TABLE 9

Mixed organic material + 0·5°/₀ P₂O₅ as Tata basic slag

Period of exposure in days	Total carbon °/₀	Total nitrogen °/₀	NH₃ — N °/₀	NO₃ — N °/₀	Total available N over Total N °/₀	pH	Conductivity × 10⁻³ (Mhos/cm)	C/N ratio
			LIGHT (Sunlight)					
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	22·99	1·4980	0·07989	0·05379	15·6	7·6	2·5	15·4
60	17·63	1·6192	0·08869	0·23838	20·2	6·9	3 2	10·9
90	13·72	1·7151	0·13806	0·27012	23·8	7·2	3·5	8·0
120	11·26	1 6652	0 09990	0·22980	19·8	8·9	3·3	6·7

			DARK					
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	23·70	1·2324	0·06217	0·09434	12·7	7·8	2·2	23·3
60	24·85	1·3125	0·06681	0·13662	15·5	7·3	2·5	18·9
90	21·72	1·3672	0·07306	0·17713	18·3	7·3	2·7	15·9
120	19·18	1·3212	0·06273	0·13147	14·7	7·5	2·5	14·5

TABLE 10

Mixed organic material + 0·5°/₀ P₂O₅ as Belgian basic slag

Period of exposure in days	Total carbon °/₀	Total nitrogen °/₀	NH₃ — N °/₀	NO₃ — N °/₀	Total available N over Total N °/₀	pH	Conductivity × 10⁻³ (Mhos/cm)	C/N ratio
			LIGHT (Sunlight)					
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	22·36	1·5154	0·08283	0·16266	16·2	7·4	2·6	14·8
60	16·77	1·6390	0·09391	0·25683	21·4	6·7	3·3	10·2
90	13·00	1·7294	0·14223	0·228146	24·5	7·3	3·6	7·5
120	10·55	1·6850	0·10289	0·23579	20·1	7·8	3·4	6·2

			DARK					
0	42·33	0·7926	—	—	—	8·2	1·3	53·5
30	27·69	1·2420	0·06589	0·10178	13·5	7·7	2·3	22·3
60	23·54	1·3252	0·06866	0·14932	16·6	7·2	2·6	17·8
90	20·92	1·3838	0·07541	0·19580	19·6	7·5	2·8	15·1
120	18·29	1·3339	0·06457	0·14034	15·4	7·6	2·6	13·7

TABLE 11

Available phosphate $\%$ during the composting of cane trash in buckets

Treatments	Available phosphate ($\%$) (1% citric acid solution)				
	NUMBER		OF		DAYS
	0	45	90	120	150
LIGHT					
2 Kgms of cane trash + 30$\%$ moisture	—	0·1362	0·1669	0·1825	0·1937
2 Kgms of cane trash + 0·25$\%$ P_2O_5 as A. R. P. "C"	—	0·2371	0·2645	0·2839	0·2951
2 Kgms of cane trash + 0·25$\%$ P_2O_5 as T. B. S.	—	0·2753	0·3146	0·3366	0·3428
2 Kgms of cane trash + 0·25$\%$ P_2O_5 as superphosphate	—	0·2493	0·2821	0·3073	0·3144
DARK					
2 Kgms of cane trash + 30$\%$ moisture	—	0·1265	0·1469	0·1572	0·1627
2 Kgms of cane trash + 0·25$\%$ P_2O_5 as A. R. P. "C"	—	0·1886	0·2193	0·2286	0·2379
2 Kgms of cane trash + 0·25$\%$ P_2O_5 as T. B. S.	—	0·2348	0·2641	0·2718	0·2803
2 Kgms of cane trash + 0·25$\%$ P_2O_5 as superphosphate	—	0·2021	0·2268	0·2358	0·2407

TABLE 12

Available phosphate ($\%$) during the composting of mixed organic material in pits

	0	30	60	90	120
LIGHT					
Mixed organic material + 60$\%$ moisture	—	0·1536	0·1828	0·2078	0·2169
Mixed organic material + 0·5$\%$ P_2O_5 as B. R. P.	—	0·1675	0·2078	0·2365	0·2477
Mixed organic material + 0·5$\%$ P_2O_5 as T. B. S.	—	0·1925	0·2445	0·2769	0·2878
Mixed organic material + 0·5$\%$ P_2O_5 as B. B. S.	—	0·1972	0·2506	0·2816	0·2945
DARK					
Mixed organic material + 60$\%$ moisture	—	0·1227	0·1448	0·1689	0·1767
Mixed organic material + 0·5$\%$ P_2O_5 as B. R. P.	—	0·1427	0·1687	0·1996	0·2039
Mixed organic material + 0·5$\%$ P_2O_5 as T. B. S.	—	0·1733	0·1876	0·2256	0·2321
Mixed organic material + 0·5$\%$ P_2O_5 as B. B. S.	—	0·1765	0·1892	0·2309	0·2385

The foregoing experimental results show that after the commencement of the composting in buckets, the temperature of the compost rose higher than the air temperature. The increase of temperature was more rapid in the phosphated compost. It was also observed that the temperature of the set exposed to light was higher than that of the covered set. After 4 to 5 days, signs of decomposition were visible and darkening of the compost had started. A reduction in volume was observed in all the composts in buckets after 45 days.

In the composting in pits, there was also rapid rise of temperature in the phosphated compost. Moreover, if the composts are exposed to sunlight, the rise in temperature is higher than in the composts receiving less sunlight. This can be observed from the tables. Later on, it was found that the volume of the composts decreased and the rate of the rise of the temperature declined.

Percentage of carbon oxidation in the bucket composts when different phosphatic fertilizers were added to the different systems

| | Treatments | Days | Carbon oxidised % | |
			Light	Dark
1.	Cane trash alone (Control)	150	45·5	35·3
2.	,, + Algerian rock phosphate "C"	150	55·5	50·2
3.	,, + Tata basic slag	150	65 5	57·2
4.	,, + Superphosphate	150	58·2	51·1

It is clear from the above results that in the phosphated composts the carbon was oxidised to a greater extent than in the unphosphated composts, both in light than in the dark.

While in the case of composting of organic materials in pits, the oxidation of carbon in different pits was as follows:

| | Treatments | Days | Carbon oxidised % | |
			Light	Dark
1.	Organic material alone	120	58·5	41·5
2.	,, ,, + Bihar rock phosphate	120	65·3	48·4
3.	,, ,, + Tata basic slag	120	73·4	54·7
4.	,, ,, + Belgian basic slag	120	75·1	56·8

From the foregoing results, it appears that the carbon was oxidised more in the phosphated compost pits both in light and in the dark than in the unphos-

phated compost pits in light and dark. It also indicates that the carbon oxidised is greater in the pits which receive sunlight than in those which receive ess sunlight in the same period.

Nitrogen increase in bucket composts when different phosphatic fertilizers were added to the different systems

| | Treatments | Days | Nitrogen increase $\%$ | |
			Light	Dark
1.	Cane trash alone (control)	120	From 0·6615 to 0·9366	0·8824
2.	,, ,, + Algerian rock phosphate "C"	90 & 120	From 0·6546 to 1·3759	1·1147
3.	,, ,, + Tata basic slag	90	From 0·6401 to 1·4133	1·1368
4.	,, ,, + Superphosphate	90 &120	From 0·6516 to 1·40555	1·1409

While in the case of composting of organic substances like mixture of grasses and dry leaves a progressive increase of nitrogen was observed

| | Treatments | Days | Nitrogen increase | |
			Light	Dark
1.	Organic material (alone)	90	From 0·7926 to 1·1270	1·0272
2.	,, ,, + Bihar rock phosphate	90	From 0·7926 to 1·4940	1·2626
3.	,, ,, + Tata basic slag	90	From 0·7926 to 1·7151	1·3672
4.	,, ,, + Belgian basic slag	90	From 0·7926 to 1·7294	1·3838

An analysis of these composts after 120 days showed some loss of nitrogen in both types of composting, i. e. cane trash composting in buckets and organic material composting in pits. This is evident from the experimental data recorded in tables. It was also observed that the C/N ratio in presence of phosphate was lower than in the absence of phosphates.

It has been found that in the above experiments the loss of nitrogen in the process of composting may be due to the higher temperature prevailing in the compost heaps and to their acidity. Moreover in composting the formation and a marked decomposition of the unstable compound intermediate compound, ammonium nitrite, in the process of nitrification of all nitrogenous substances takes place:—

$$\text{Proteins} \longrightarrow \text{amino acid} \xrightarrow{+O_2} \text{nitrite} \xrightarrow{+O_2} \text{nitrate}$$

$$NH_4NO_2 = N_2 + 2H_2O + 718 \text{ K. Cals.}$$

[532]
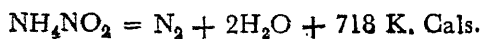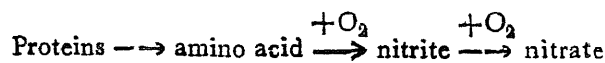
Hence, along with the fixation of nitrogen and formation of proteins and other nitrogenous compounds side by side ammonification and nitrification are taking place. These oppose the increase of proteins and other nitrogen compounds in the compost heaps that is taking place and, thus, the amount of proteins remaining in the compost heaps tends to decrease. Consequently, a loss of nitrogen is observed. But, in the presence of large amounts of phosphates in the system, more or less stable phospho-proteins are formed by the combination of phosphates and proteins. These compounds seen to resist ammonification and nitrification and the loss of nitrogen appears to be less than with proteins alone. Vpas (3) and other workers have found that by the use of superphosphate the loss of nitrogen could be reduced in manure heap, where a part of the ammonia given off in nitrification is adsorbed by the superphosphate. We have also found in our experiments that the available phosphate is greater in light than in the dark, even with an equal dose of P_2O_5. This is due to the fact that the tricalcium phosphate, which is present in rock phosphate and basic slags is converted into more soluble form of phosphates such as dicalcium phosphate and monocalcium phosphate by the action of carbonic acid and the organic and inorganic acids produced during the decomposition, ammonification, and nitrification of the added organic matter accelerated by light absorption. This is clear from the following equations:—

1. $Ca_3 (PO_4)_2 + CO_2 + H_2O \rightarrow CaHPO_4 + CaCO_3$

2. $Ca_3 (PO_4)_2 + 2CO_2 + 2H_2O \rightarrow Ca (HPO_4)_2 + 2CaCO_3$
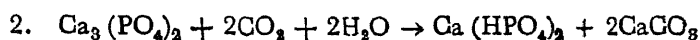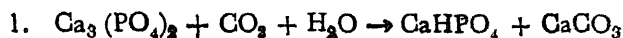
The weak organic acids formed in the slow oxidation of organic matter and the nitric and nitrous acids formed in the nitrification of the nitrogenous compounds make the phosphates available from the system and this is a very valuable function of a mixture of organic matter and sparingly soluble calcium phosphates including basic slag in land fertility improvement.

The following observation of Dhar (4) are of great interest in this connection:—

"The third dissociation constant of phosphoric acid is smaller than the first and the second dissociation constants of the carbonic acid and, hence, carbonic acid converts tricalcium phosphate into dicalcium phosphate, which is more soluble than tricalcium phosphate. Thus, the availability of phosphate is increased in soil rich in carbonic acid obtained from the oxidation of organic substances. Similarly, nitrous and nitric acids, formed in the soil from ammonification and nitrification of proteins, make phosphate more readily available. Thus, phosphates are more useful in presence of organic substances like farmyard manure, straw etc. undergoing slow oxidation".

The above view of Dhar have also been supported by several workers, like Rahn (5), McGeorge (6) and others, who have found that organic matter was specially valuable in increasing the value of phosphatic manures on alkaline calcareous soils.

In this way, more carbonic acid, nitrous and nitric acids are available in the composting of plant materials and, thus, convert the tricalcium phosphate and rock phosphate and basic slags to more soluble forms of phosphates, such as monocalcium phosphates and dicalcium phosphates.

Upto a certain intervals of time, the pH of the exposed composts is smaller than that of the covered, but, as soon as the breakdown of the acids and minera-

lisation begin, the exposed composts become slightly more alkaline than the covered ones. In the beginning, the conductivity of the exposed composts is much greater than that of the covered, but, later on, this difference in the conductivity decreases.

From the study of the foregoing results it has been observed by us that the total and available nitrogen are greater in the phosphated and exposed composts than in the unphosphated and the covered ones.

From these experiments it has been observed that the composting of cane trash and other organic substances when incorporated with phosphates in presence of light, improves the nitrogen status of the composts and they can be utilised in building up the land fertility permanently.

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A QUANTAL INTERPRETATION OF MOLECULAR DISSOCIATION AND THE KINETICS OF THERMAL AND PHOTOCHEMICAL REACTIONS

PREM BEHARI MATHUR

Central Electrochemical Research Institute, Karaikudi 3

ABSTRACT

The mechanism of moleculor dissociation has been explained in the light of various energy states of a molecule. Postulations are made that : A molecule cannot decompose at its electronic ground level and the thermal and photochemical dissociations of a molecule cannot be two distinctively different processes as conceived by Franck; A molecule ruptures only when the requisite units of each of rotational, vibrational and electronic types of bond energies are received by it. Activation energy and preexponential factor of Arrhenius equation have been interpreted in terms of spectroscopic parameters of a molecule.

INTRODUCTION

Franck[1] visualised the dissociation of a molecule in the excited and in the ground states as two distinctively different processes. The energy $h\,\nu_{conv.}$ corresponding to the convergence frequency ν_{conv} is equated[2] to the sum of the energy of dissociation (D_o^o) of a molecule from the electronic ground state into two atoms, and the energy of excitation $h\,\nu_e$ or E_{atoms} of one of the atoms. so,

$$h\,\nu_{conv.} = D_o^o + h\,\nu_e \qquad (1)$$

Disagreeing with Franck's above mentioned view the author is presenting here a different model of molecular dissociation, and based on this model a theory for the kinetics of thermal and photochemical reactions.

THE THEORY

Molecules are raised to higher energy levels in their various degrees of freedom on being exposed to radiations in their surroundings. A molecule, however, requires a minimum amount of each of the various bond energies (rotational-vibrational and electronic) for its decomposition. The thermal energy of excitation D_o^o renders a separation between the atomic nuclei; yet the atoms cannot fly apart resulting in the breakdown of the molecule so long the valence electron too is not raised to its excitation energy level. Since the two types of unlocking viz., (a) seaparation of atomic nuclei and (b) excitation of valence electron are imperative for the rupture of a molecule, the author postulates that molecules do not decompose at their electronic ground level and that the thermal and photochemical dissociation of molecules can not be two distinctly different processes as conceived by Franck. The so-called heat of dissociation D_c^o of a molecule is not the true dissociation energy of a molecule. The real energy of dissociation of a molecule is $D_o^o + h\,\nu_e$ or say $h\,\nu_{conv.}$ When $h\,\nu e$ is sufficiently

small in comparison to D_o^o , as is the case in several molecules, the decomposition may appear thermal though the molecule may not decompose at the electronic ground level; when $h\,ve$ is comparable or larger than D_o^o , v_{conv} may lie on the higher frequency side and the reaction would appear photosensitive. (It may be noted that the electronic spectra frequencies do not represent electronic excitation energies).

Finer structure of a Radiation Quantum: When a radiation is absorbed by a molecule, the energy of the radiation quantum $h\nu$ is shared as the author postulates here, by the two distinctly different degrees of freedom viz., (a) rotational-vibrational and (b) electronic exactly in the same proportions ε_t and ε_e respectively which are responsible for building up the same quantum of energy at the time of its emission from the matter. The following relation is, therefore, true for both the absorption as well as the emission processes:

$$h\,\nu \rightleftharpoons \varepsilon_t + \varepsilon_e \qquad (2)$$

The proportion ε_t of a radiation quantum in a thermal and in infrared region is usually very large and decreases in optical region, while ε_e increases from infrared to optical and ultra violet regions. So, in chemically active region of the radiation spectrum as one type of energy increases the other decreases. This complementary nature of the radiations is mainly responsible for their specific character in physiochemical phenomena.

Molecules break by particular frequencies (ν) which are characteristics of them. When $\varepsilon_e = 0$ or sufficiently small in comparison to ε_t any frequency within the region of thermal radiations and possesing the energy $h\,\nu = \varepsilon_t$ will decompose the molecule. Similarly when ε_t for the molecular system is zero or negligibly small in comparison to ε_t the molecule will be decomposed by the photoradiations of frequencies greater than the lowest characteristic frequency v_{conv}. Consequently frequencies other than characteristic frequency also bring about the chemical transformation when either ε_t or ε_e being negligibly small rendering the reaction to become ideally thermal or photochemical.

Reaction Kinetics: When matter is exposed to radiations at a particular temperature, an equilibrium between the particles of matter and different forms of bond energies is established. If n_i denotes the number of molecules having the translational, totational-vibrational energy ε_t per gr. mole, then the thermal equilibrium attained by the system can be represented by Maxwell-Boltzmann Law

$$n_i = n_o e^{-\varepsilon_t'/AT}$$

$$\text{or } \alpha = \frac{n_i}{n_o} = e^{-\varepsilon_t'/RT}$$

where n_0 is the total number of molecules per unit volume, T the absolute temperature, R gas constant, and α the fraction of the total gram molecules always present in a system in a state of thermal excitation.

The problem is now to find out the time taken for the dissociation of this fraction α. When an active radiation is absorbed by a molecular system, the bond electrons in all the molecules are simultaneously raised from their ground state to excited dissociation state (application of Frank-Conden Principle[3]) and so all the molecules get polarised though the thermal excitation takes place only in a fraction of the total molecules. The fraction of the molecules which is therefore in a state of electronic as well as thermal excitation at any moment will also be α, and consequently this fraction will break repeatedly. Now, the time taken for the electronic excitation must bear a relationship with the energy of electronic excitation. The author postulates that this time is equivalent to $1/v_e$ where v_e is the electronic excitation frequency of the molecule (ref eq. 1). Evidently $1/v_e$ will be the period of dissociation of a molecule. As α fraction of the total number of molecules, is always present in a state of thermal excitation, $1/v_e$ second will be required to break α fraction, and therefore, one second to break v_e α fraction of of the molecules. Let us put

$$k = v_e\, \alpha \tag{8}$$

$$\text{or } k = v_e\, e^{-\,\varepsilon'_t/RT} \tag{9}$$

Since v_e and α are constants for a particular system, k will be a constant. Equation (9) is similar to Arrhenius equation of chemical kinetics.

Activation Energy: The total dissociation energy of a molecular system is known from its electronic absorption spectrum to be $h\, v_{conv.}$ where $v_{conv.}$ is the limit of descrete spectrum or the beginning of continuous absorption spectrum. This energy ($h\, v_{conv.}$) is constituted of electronic excitation energy needed to raise the valence electron to excitation energy level and the internal energy possessed in various degrees of freedoms other than 3 translational and 3 rotational devoted to the molecule as a whole. The author considers that the activation energy factor of Arrhenius equation, represents the total thermal energy of a molecular system before dissociation. Thus in equation (4) ε_t may be equated to

ε_t = (Internal Thermal Energy) + (Translational + Rotational Energy)

$$\text{or } \varepsilon_t = [N\, h\, (v_{conv.} - m\, v_e) + 6\, (RT/2) \tag{10}$$

$$= [N\, h\, (v_{conv.} - v_e) - N\, h\, (m-1)\, v_e] + 3RT \tag{11}$$

Since, $N\, h\, (v_{conv.} - v_e) = D^0_0$, we have

$$\varepsilon_t = D^0_0 - (m-1)\, N\, h\, v_e + 3\, RT \tag{12}$$

Here 'm' is the order of a reaction. The significance of 'm' can be understood from the example cited below. Consider the following reactions:

$$A_2 \rightarrow A + A \tag{I}$$

$$AB \rightarrow A + B \rightarrow \tfrac{1}{2}A_2 + \tfrac{1}{2}B_2 \tag{II}$$

Reaction (I) and the first step in reaction (II) would involve one unit of electronic excitation energy $h\,v_e$ for the dissociation of the molecule A_2 or AB into atoms. Since the second process viz., the union of atoms in the second reaction is two body collision, it will not be instantaneous and the excited atom will radiate out its energy before two bodies meet and their union may take place. So a quantum of electronic excitation energy $h\,v_e$ would again be needed to raise the valence electron to an excited state and thus to activate the atom and bring about the union of the atoms. The reaction (II) which is of second order, would thus, take up 2 units of electronic excitation energy and similarly mth order reaction will take $m\,h\,v_e$ units of the energy. Substituting the value of ϵ_t from equation (12) in equation (9) we have,

$$K = v_e\,e^{-[\overset{o}{D_0} - (m-1)\,N\,h\,v_e + 3RT]/RT} \tag{13}$$

when $m = 1$, for a uni molecular reaction

$$K = v_e\,.\,e^{-(\overset{o}{D_0} + 3RT)/RT} \tag{14}$$

or

$$K = (v_e\,.\,e^{-3})\,e^{-\overset{o}{D_0}/RT} \tag{15}$$

The frequency factor for second and higher order reactions will be given in a subsequent communication.

Equation (14) represents the kinetics of unimolecular reactions, and it is of the same form as the Arrehenius equation of chemical kinetics $K = A\,e^{-E/RT}$. Here, preexponential and exponential factors[*] are as follows.

TABLE

Preexponential Factor	Exponential Factor
v_e^-	$\overset{o}{D_0} + 3RT - Nh\,(m-1)\,v_e$
or $\quad v_e\,e^{-3}$	$\overset{o}{D_0} - Nh\,(m-1)\,v_e$

Arrehenius Frequency Factor: Earlier attempts of interpreting the frequency factor have been discussed by Gowenlock[3] in his review on 'Arrhenius Factors (Frequency Factor) in unimolecular reactions). It is of interest to note that the order of vibrational frequencies is 10^{12} sec^{-1}. Whereas Arrhenius Factor has values as high as 10^{16} sec^{-1} and as low as 10^2 sec^{-1}. Only the electronic excitation frequency vary within this wide range.[6]

Photochemical Reactions: A reaction will be photochemical provided the heat of activation of the reaction

$$\cdot - [Nh\,(\nu_{ccav.} - m\,\nu_e) + 3RT] \approx 0 \text{ or low}$$

Evidently, a reaction will be photosensitive when (a) the electronic excitation energy $h\,\nu_e$ (or E_{atom}) is high and (b) the heat of dissociation D_o^o which is equal to $h\,N\,(\nu_{conv.} - \nu_a)$ is low. From the data given in reference 2, it may be noted that chlorine requires largest amount of heat of disociation, bromine lesser and iodine molecule least; while electronic activation energy E_{atom} is maximum for iodine and least for chlorine. Evidently iodine should be more photosensitive than bromine and chlorine and bromine more than chlorine. This is in confirmity with the known facts.

In a case where $D_o^o = 0$, the equation (15) reduces to

$$K = \nu_a\,e^{-3} = \nu_{conv.}\,e^{-3}$$

or

$$E = h\,k\,e^3 = h\,\nu_e = \text{constant} \quad (16)$$

Where ν_e signifies to the threshold frequency. $h\,\nu_e$ would be the energy needed by a molecule for its rupture in an ideal photochemical process, which does not require any thermal energy D_o^o to excite the molecule in its rotational and vibrational levels (vide page 3). Only under such ideal conditions the reaction kinetics equation (14) reduces to Einstein Law of photochemical equivalence (equation 16), which states that each single molecule of photosensitive subtance requires just one quantum $h\,v$ of the active radiation for its dissociation.

Kinetics of the Decomposition of Iodine: For iodine molecule the relevant spectroscopic data as well as experimental value for the rate constant of dissociation are available in literature. Noyes[7] has studied this reaction and has obtained $1\cdot4\times10^{-19}$ sec^{-1}. as the rate constant at 36°C. Using the following simplified form of the first order equation (14), the rate constant can be given by:

$$\log k = \log(C.\ E_{atom}) - \left[\frac{D_o^o}{2\cdot3RT} - \frac{3}{2\cdot3} \right] \quad (17)$$

where C is the velocity of light and E_{atom} the wave number corresponding to the electronic excitation frequency. Substituting the values of C, R, E_{atom} and D_o^o for iodine molecule, the rate constant at 36°C will be given by:

$$\log k = \log[(3\times10^{10})(7598)] - \left[\frac{35380}{2\cdot3\times2\times209} + \frac{3}{2\cdot3} \right]$$

or

$$k = 1\cdot457\times10^{-12}\ \text{Sec}^{-1}.$$

The extremely good agreement between the theoretically calculated value of the reaction constant and the value obtained by Noyes indicates the validity of the concepts advanced and the rate equation given in this paper. The present theory explains the specific role played by the radiation frequencies in various photochechemical processes occurring in nature.

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CERTAIN INTEGRAL REPRESENTATIONS FOR THE MEIJER TRANSFORM

By

K. C. GUPTA*

Department of Mathematics, University of Rajasthan, Jaipur

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ABSTRACT

In this paper we prove two theorems on the Meijer transform, defined by

$$\phi\,(p) \;=\; \left(\frac{2}{\pi} \right)^{\frac{1}{2}} p \int_{0}^{\infty} (pt)^{\frac{1}{2}} \; K_{\nu}\,(bt)\, h\,(t)\, dt.$$

Later on we use these theorems for finding integral representations for Bessel and E-functions.

1. Meijer (3) gave the generalization of Laplace's integral

$$\phi\,(p) \;=\; p \int_{0}^{\infty} e^{-pt}\, h\,(t)\, dt, \tag{1·1}$$

in the form

$$\phi\,(p) \;=\; \left(\frac{2}{\pi} \right)^{\frac{1}{2}} p \int_{0}^{\infty} (pt)^{\frac{1}{3}} \; K_{\nu}\,(pt)\, h\,(t)\, dt, \tag{1·2}$$

(1·2) reduces to (1·1) when $\nu = \pm \frac{1}{2}$, by virtue of the identity

$$K_{\pm \frac{1}{2}}(x) \;=\; \left(\frac{\pi}{2x} \right)^{\frac{1}{2}} e^{-x} \tag{1·3}$$

Recently (1), (2) we had obtained a few results involving the transform (1·2). Here we use them for establishing two theorems and evaluating a few infinite integrals. Many theorems recently obtained by Sharma (5) and Saxena (4) follow as particular cases of our findings.

Throughout this paper (1·1) and (1·2) shall be denoted symbolically as

$$\phi\,(p) \doteqdot h\,(t) \quad \text{and} \quad \phi\,(p) \underset{\nu}{\overset{k}{=\!=}} h\,(t)$$

respectively and the symbol $\triangle\,(l, a)$ will be used to represent the set of parameters

$$\frac{a}{l}\,,\, \frac{a+1}{l}\,,\, \dots\,,\, \frac{a+l-1}{l}$$

Present address : Malavia Regional Engineering College, Jaipur.

In what follows n and s are positive integers.

2. *Theorem 1.* If

and
$$\phi(p) \xrightleftharpoons[\mu]{k} h(t)$$

$$\psi(p) \xrightleftharpoons[\nu]{k} t^{n/s}(\lambda + 3/2) h(t^{n/s}),$$ (2·1)

then

$$\phi(p) = p^{\lambda + 3/2 - s/n} (2s)^{s/n - \lambda - 1} (2\pi)^{n - s} (2n)^{-\frac{1}{3}}$$

$$\times \int_{\xi}^{\infty} \psi(t) \, G_{2n, \, 2s}^{2s, \, 0} \left[\left(\frac{p}{2s}\right)^{2s} \left(\frac{2n}{t}\right)^{2n} \, \Bigg| \, \begin{matrix} \triangle\left(n, \dfrac{5 \pm 2\nu}{4}\right) \\ \triangle\left(s, \tfrac{1}{2}(s/n \pm \mu - \lambda)\right) \end{matrix} \right] dt,$$ (2·2)

where $\xi = 0$ if $\dfrac{n}{s} < 1$ and $\xi \to p$ as $\dfrac{n}{s} \to 1$ provided that the integral is conver-

gent, the Meijer transforms of $|h(t)|$ and $|t^{n/s}(\lambda + 3/2) h(t^{n/s})|$ exist,

$$\frac{n}{s} \leq 1 \text{ and } R(p) > 0.$$

Proof. In an earlier paper (1) it has been shown that

$$p^{-n/s \, \lambda} \, K_\mu(a \, p^{n/s}) \xrightleftharpoons[\nu]{k} \sqrt{\pi/2} \left(\frac{a}{2s}\right)^\lambda (2\pi)^{n-s} (2n)^{-\frac{1}{3}}$$ (2·3)

$$\times G_{2n, \, 2s}^{2s, \, 0} \left[\left(\frac{a}{2s}\right)^{2s} \left(\frac{2n}{t}\right)^{2n} \, \Bigg| \, \begin{matrix} \triangle\left[n, \dfrac{3 \pm 2\nu}{4}\right] \\ \triangle\left(s, \tfrac{1}{2}(\pm \mu - \lambda)\right) \end{matrix} \right]$$

where $|\arg a| < (s - n)\dfrac{\pi}{2s}$ and $R(p) > 0$ if $\dfrac{n}{s} < 1$ and $t \geq a$ as $\dfrac{n}{s} \to 1$.

Using (2·1) and (2·3) in the Parseval-Goldstein theorem for the Meijer transform, which states that if

$$\phi_1(p) \xrightleftharpoons[\nu]{k} g_1(t) \text{ and } \phi_2(p) \xrightleftharpoons[\nu]{k} g_2(t)$$

then

$$\int_0^\infty \phi_1(t) \, g_2(t) \, t^{-1} \, dt = \int_0^\infty \phi_2(t) \, g_1(t) \, t^{-1} \, dt,$$

[542]

We easily have

$$\int_0^\infty t^{3/2\, n/s\, -\, 1}\, K_\nu\, (a\, t^{n/s})\, h\, (t^{n/s})\, dt = \sqrt{\pi/2}\left(\frac{a}{2s}\right)^\lambda (2\pi)^{n\, -\, s}\, (2n)^{-\frac{1}{2}}$$

$$\times \int_\xi^\infty \psi\, (t)\cdot\frac{1}{t}\cdot G_{2n,\, 2s}^{2s,\, 0}\left[\left(\frac{a}{2s}\right)^{2s}\left(\frac{2n}{t}\right)^{2n}\left|\begin{array}{c}\Delta\left(n,\dfrac{3\pm 2\nu}{4}\right)\\[4pt]\Delta\left(s,\tfrac{1}{2}(\pm\mu-\lambda)\right)\end{array}\right.\right]\, dt \quad (2\cdot4)$$

where $\xi = 0$ if $\dfrac{n}{s} < 1$ and $\xi \rightarrow a$ as $\dfrac{n}{s}\rightarrow 1$.

On interpreting L.H.S. of (2·4) with the help of (1·2) we arrive at the theorem.

Corollary. When $\mu = \pm\tfrac{1}{2}$ the theorem can be put in the following form :—

If

$$\phi\, (p) \doteqdot h\, (t)$$

and

$$\psi\, (p) \underset{\nu}{\overset{k}{=\!=\!=}} t^{n/s\, (\lambda\, +\, 3/2)}\, h\, (t^{n/s}),$$

then

$$\phi\, (p) = p^{\lambda\, +\, 3/2\, -\, s/n}\, (2s)^{s/n\, -\, \lambda\, -\, 1}\, (2\pi)^{n\, -\, s}\, (2n)^{-\frac{1}{2}}$$

$$\times\int_\xi^\infty \psi\, (t)\, G_{2n,\, 2s}^{2s,\, 0}\left[\left(\frac{p}{2s}\right)^{2s}\left(\frac{2n}{t}\right)^{2n}\left|\begin{array}{c}\Delta\left(n,\dfrac{5\pm 2\nu}{4}\right)\\[4pt]\Delta\left(s,\tfrac{1}{2}\left(s/n-\lambda\pm\tfrac{1}{2}\right)\right)\end{array}\right.\right]\, dt \quad (2\cdot5)$$

where $\xi = 0$ if $\dfrac{n}{s} < 1$ and $\xi \rightarrow p$ as $\dfrac{n}{s}\rightarrow 1$, provided that the integral is convergent, the Laplace transform of $|\, h(t)\, |$ and the Meijer transform of $|\, t^{n/s\, (\lambda\, +\, 3/2)}$ $h\, (t^{n/s})\, |$ exist, $n/s < 1 \leqq 1$ and $R\, (p) > 0$.

On taking $n = s = 1$ in (2·5) we obtain a theorem recently obtained by Sharma (5, p 112).

3. If we use the formula (1)

$$p^{n/s\, \lambda}\, K_\mu\, (a\, p^{-n/s})\underset{\nu}{\overset{k}{=\!=\!=}}\left(\frac{a}{s}\right)^\lambda (2\pi)^{n\, -\, s\, +\, \frac{1}{2}}\, 2^{-\lambda\, -\, 1}\, (2n)^{-\frac{1}{2}}$$

$$\times G_{0,\, 2s\, +\, 2n}^{2s,\, 0}\left[\left(\frac{a}{2s}\right)^{2s}\left(\frac{t}{2n}\right)^{2n}\left|\Delta\left(s,\dfrac{\pm\mu-\lambda}{2}\right),\Delta\left(n,\dfrac{1\pm 2\nu}{4}\right)\right.\right] \quad (3\cdot1)$$

where $s > n$, $|\arg a| < (s - n) \dfrac{\pi}{2s}$ and $R(p) > 0$, then by a similar procedure as adopted in the proof of theorem 1, we obtain

Theorem 2. If

$$\phi(p) \xmapsto[\mu]{k} h(t)$$

and

$$\psi(p) \xmapsto[\nu]{k} t^{-n/s\,(\lambda + 3/2)} h(t^{-n/s}),$$

then

$$\phi(p) = p^{\lambda + 3/2 + s/n} (2s)^{-(\lambda + 1 + s/n)} (2\pi)^{n-s} (2n)^{-\frac{1}{2}}$$

$$\times \int_0^\infty \psi(t)\, G_{0,\,2s+2n}^{2s,\,0} \left[\left(\frac{p}{2s}\right)^{2s} \left(\frac{t}{2n}\right)^{2n} \middle| \Delta\left(s, \tfrac{1}{2}(\pm\mu - \lambda - \tfrac{s}{n})\right), \right.$$

$$\left. \Delta\left(n, \frac{\pm 2\nu - 1}{4}\right) \right] dt, \quad (3\cdot2)$$

provided that the integral is convergent, the Meijer transforms of $|h(t)|$ and $\left| t^{-n/s\,(\lambda + 3/2)} h\left(t^{-n/s}\right) \right|$ exist, $s > n$ and $R(p) > 0$.

Corollary. On taking $n = 1$, $(3\cdot2)$ give rise to the following result :—

If

$$\phi(p) \xmapsto[\mu]{k} h(t)$$

and

$$\psi(p) \xmapsto[\nu]{k} t^{-1/s\,(\lambda + 3/2)} h(t^{-1/s}),$$

then

$$\phi(p) = (2)^{-\frac{1}{2}} p^{\lambda + 3/2 + s} (2s)^{-(\lambda + s + 1)} (2\pi)^{1-s}$$

$$\times \int_0^\infty \psi(t)\, G_{0,\,2s+2}^{2s,\,0} \left[\frac{p}{2s} \middle|^{2s} \frac{t^2}{4} \middle| \Delta\left(s, \tfrac{1}{2}(\pm\mu - \lambda - s)\right), \tfrac{1}{4}(2\nu - 1), \right.$$

$$\left. -\tfrac{1}{4}(2\nu + 1) \right] dt, \quad (3\cdot3)$$

[544]

provided that the integral is convergent, the Meijer transforms of $|\ h(t)\ |$ and

$\left|\ t^{-1/s\ (\lambda\ +\ 3/2)}\ h\ (t^{-1/s})\ \right|$ exist and R $(p) > 0$.

When $s \rightarrow 1$ and $\nu = \pm \tfrac{1}{2}$ in (3·3), it reduces to a known result (4, p. 167).

4. Here we give certain integral representations for Bessel and E-functions, which have been obtained by the applications of theorems 1 and 2.

Example 1. If we take (1)

$$\phi\ (p) = E\left(a_1,\ ...,\ a_l : b_1,\ ...,\ b_m : \frac{1}{p}\right) \frac{k}{\mu}\ \sqrt{\pi}\ (2\pi)^{\frac{1}{2}\ (m-l-1)}$$

$$2^{\sum\limits_{i=1}^{l}\ (a_i)\ -\ \sum\limits_{J=1}^{m}\ (b_j)\ +\ \frac{1}{2}\ (m\ +\ 1\ -\ l)}$$

$$\times\ G^{2l,\ 2}_{2m\ +\ 2,\ 2l\ +\ 2}\left[\frac{t^2}{2^2\ (l\ -\ m)}\ \left|\ \begin{matrix}\frac{1}{2},\ 1,\ \frac{b_1}{2}\ ,\ \frac{b_1\ +\ 1}{2}\ ,\ ...\ ,\ \frac{b_m}{2}\ ,\ \frac{b_m\ +\ 1}{2}\\[4pt]\frac{a_1}{2},\ \frac{a_1\ +\ 1}{2},...,\ \frac{a_l}{2}\ ,\ \frac{a_l\ +\ 1}{2}\ ,\ \frac{1\ +\ 2\mu}{4}\ ,\ \frac{1\ -\ 2\mu}{4}\end{matrix}\ \right]\ \begin{matrix}h(t),\\t\end{matrix}$$

where R $(\min a_h \pm \mu \pm 3/2) > 0$, $(h = 1, 2, ... , l)$, $l > m$

and R $(p) > 0$. We then have from (2)

$$h\ (t^{n/s}) = \sqrt{\pi}\ (2\pi)^{\frac{1}{2}\ (m-\ l\ -\ 1)\ \sum\limits_{i=1}^{l}\ (a_i)\ -\ \sum\limits_{j=1}^{m}\ (b_j)\ +\ \frac{1}{2}\ (m\ +\ 1\ -\ l)}_{2}$$

$$\times\ G^{2l,\ 2}_{2m\ +\ 2,\ 2l\ +\ 2}\left[\frac{t^{2n/s}}{2^2\ (l\ -\ m)}\ \left|\ \begin{matrix}\frac{1}{2},\ 1,\ \frac{b_1}{2},\ \frac{b_1\ +\ 1}{2}\ ,\ ...\ ,\ \frac{b_m}{2}\ ,\ \frac{b_m\ +\ 1}{2}\\[4pt]\frac{a_1}{2},\ \frac{a_1\ +\ 1}{2},\ ...\ ,\ \frac{a_l}{2},\ \frac{a_l\ +\ 1}{2},\ \frac{1\ +\ 2\mu}{4}\ ,\ \frac{1\ -\ 2\mu}{4}\end{matrix}\ \right]$$

$$\frac{k}{\nu}\ (2\pi)^{\frac{1}{2}\ -\ n\ +\ (l\ -\ m)(\frac{1}{2}\ -\ s)}\ (2s)^{\sum\limits_{i=1}^{l}\ (a_i)\ -\ \sum\limits_{j=1}^{m}\ (b_j)\ +\ \frac{1}{2}\ (m\ -\ l)}\ (2n)^{\frac{1}{2}}$$

$$\times \, \mathrm{G}^{2s+2n,\;2l\,s}_{(2l+2)\,s,\;2n+(2m+2)s} \left[(2s)^{2s}\,(l-m)\left(\frac{p}{2n}\right)^{2n} \left| \begin{array}{l} \Delta\left(s,\dfrac{1-a_1}{2}\right)\Delta\left(s,\dfrac{2-a_1}{2}\right),\dots,\\[2mm] \Delta\left(s,\dfrac{2-a_1}{2}\right),\Delta\left(s,\dfrac{3\pm2\mu}{4}\right)\\[2mm] \Delta\left(n,\dfrac{3\pm2\nu}{4}\right),\Delta(s,0),\Delta(s,\tfrac12),\\[2mm] \Delta\left(s,\dfrac{1-b_1}{2}\right),\Delta\left(s,\dfrac{2-b_1}{2}\right),\dots,\\[2mm] \Delta\left(s,\dfrac{2-b_m}{2}\right) \end{array} \right. \right]$$

$$= \psi\,(p),$$

where $\mathrm{R}\,(\min na_h \pm \nu s + \tfrac{3}{2}\,s) > 0$, $(h = 1, 2, \dots, l)$ and $\mathrm{R}\,(p) > 0$.

Substituting the values of $\phi\,(p)$ and $\psi\,(p)$ in (2·2) with $\lambda = -\dfrac{3}{2}$, it is found that

$$\int_{\xi'}^{\infty} \mathrm{G}^{2s,\,0}_{2n,\,2s}\left[\frac{p}{t} \,\left|\, \begin{array}{ll} \Delta & \left(n,\dfrac{4n+3\pm2\nu}{4}\right)\\[2mm] \Delta & \left(s,\dfrac{4s+3\pm2\mu}{4}\right) \end{array} \right. \right]$$

$$\times \, \mathrm{G}^{2s+2n,\;2l\,s}_{(2l+2)\,s,\;2n+(2m+2)s} \left[(2s)^{2s}\,(l-m-1)\,t\, \left| \begin{array}{l} \Delta\left(s,\dfrac{1-a_1}{2}\right),\Delta\left(s,\dfrac{2-a_1}{2}\right),\dots,\\[2mm] \Delta\left(s,\dfrac{2-a_1}{2}\right),\Delta\left(s,\dfrac{3\pm2\mu}{4}\right)\\[2mm] \Delta\left(n,\dfrac{3\pm2\nu}{4}\right),\Delta(s,0),\Delta(s,\tfrac12),\\[2mm] \Delta\left(s,\dfrac{1-b_1}{2}\right),\Delta\left(s,\dfrac{2-b_1}{2}\right),\dots,\\[2mm] \Delta\left(s,\dfrac{2-b_m}{2}\right) \end{array} \right. \right] dt.$$

$$= p\,(2\pi)^{(s-\frac12)(l-m+1)} (2s)^{\sum\limits_{j=1}^{m}(b_j)\;-\;\sum\limits_{i=1}^{l}(a_i)+\frac12(l-m-1)}$$

$$\times \, \mathrm{E}\,(a_1, \dots, a_l : b_1, \dots, b_m : p^{-\frac12 s}) \qquad (4\cdot1)$$

where $\xi' = 0$ if $\dfrac{n}{s} < 1$ and $\xi' \to p^{\frac12 s}$ as $\dfrac{n}{s} \to 1$.

[546]

Provided that $s \gtreqless n$, $R\left(2s + a_h \pm \mu - \frac{1}{2}\right) > 0$ $(h, = 1, 2, \ldots, l)$ and $\left|\arg p\right|$

$< (s - n)\dfrac{\pi}{2s}$.

Example 2. If we take (1)

$$\phi(p) = p^\rho \, K_\lambda \left(2 p^{\frac{1}{2}}\right) \frac{k}{\mu} \, \tfrac{1}{2} \cdot (2n)^{\rho - \frac{1}{2}} (2\pi)^{-\frac{1}{2}} t^{-\rho}$$

$$\times G_{2,\,4}^{4,\,0}\left[\frac{1}{4t^2} \,\middle|\, \begin{array}{c} \dfrac{3 + 2\mu - 2\rho}{4},\ \dfrac{3 - 2\mu - 2\rho}{4} \\[4pt] -\dfrac{\lambda}{4},\ \dfrac{\lambda}{4},\ \dfrac{2-\lambda}{4},\ \dfrac{2+\lambda}{4} \end{array}\right] = h(t),$$

we then have from (2)

$$h\left(t^{-n/s}\right) = \tfrac{1}{2}(2n)^{\rho - \frac{1}{2}}(2\pi)^{-\frac{1}{2}} t^{n/s\,\rho} G_{2,\,4}^{4,\,0}\left[\left(\frac{t}{4}\right)^{2n/s} \,\middle|\, \begin{array}{c} \dfrac{3 + 2\mu - 2\rho}{4},\ \dfrac{3 - 2\mu - 2\rho}{4} \\[4pt] -\dfrac{\lambda}{4},\ \dfrac{\lambda}{4},\ \dfrac{2-\lambda}{4},\ \dfrac{2+\lambda}{4} \end{array}\right]$$

$$\frac{k}{\nu} \tfrac{1}{2}(2n)^{\rho/s\,(n+s)}(2\pi)^{1-n-s} p^{-n/s\,\rho} s^{\rho - \frac{1}{2}}$$

$$\times G_{4s,\,2n+2s}^{2n,\,4s}\left[(2s)^{2s}\left(\frac{p}{2n}\right)^{2n} \,\middle|\, \begin{array}{c} \Delta\left(s, \dfrac{2\pm\lambda}{4}\right),\ \Delta\left(s, \dfrac{4\pm\lambda}{4}\right) \\[6pt] \Delta\left(n, \dfrac{3s+2n\ \rho\pm2\nu s}{4s}\right),\ \Delta\left(s, \dfrac{2\rho\pm2\mu+1}{4}\right) \end{array}\right]$$

$$= \psi(p)$$

where $R(2n\rho \pm n\lambda \pm 2\nu s + 3s) > 0$ and $R(p) > 0$.

Applying (3·2), we obtain

$$\int_0^\infty t^{1/2ns\,(s-\rho n-2ns)} G_{0,\,2s+2n}^{2s,\,0}\left[t \,\middle|\, \Delta\left(s, \dfrac{3\pm2\mu}{4} - \dfrac{s}{2n}\right), \right.$$

$$\left. \Delta\left(n, \dfrac{\pm2\nu-1}{4}\right)\right]$$

$$\times G_{4s,\,2n+2s}^{2n,\,4s}\left[\left(\frac{4s^2}{p}\right)^{2s} \cdot t \,\middle|\, \begin{array}{c} \Delta\left(s, \dfrac{2\pm\lambda}{4}\right),\ \Delta\left(s, \dfrac{4\pm\lambda}{4}\right) \\[6pt] \Delta\left(n, \dfrac{3s+2n\rho\pm2\nu s}{4s}\right),\ \Delta\left(s, \dfrac{2\rho+1\pm2\mu}{4}\right) \end{array}\right] dt$$

[547]

$$= \frac{1}{\pi} (2\pi)^{\frac{1}{2}s} n^{\frac{1}{2} - \rho} K_\lambda \left(2p^{\frac{1}{2}} \right), \tag{4.2}$$

where $s > n$, $| \arg p | < (s-n) \dfrac{\pi}{2s}$ and $R \left\{ n \left(\pm 2\mu + 3 \right) + s \left(\pm 2\nu + 3 \right) \right\} > 0.$

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STUDIES IN ALKYL ESTERS OF 1-HYDROXY PHOSPHONIC ACID

PART II

By

K. D. SHARMA *and* J. B. LAL

H. B. Technological Institute, Kanpur

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ABSTRACT

In the present investigation, authors have attempted to synthesise some new O, O dialkyl 1 hydroxy phosphonates by condensing O nitro cinnamicaldehyde and 3-methoxy 4-hydroxy benzaldehyde w th dimethyl, diethyl, dipropyl, diisopropyl, dibutyl, diisobutyl, diisoamyl and disecamyl hydrogen p osphites in the presence of sodium m thylete (few drops) as catalyst. Reaction occurred readily with O-nitrocinnamic aldehyde but phenolic aldehydes formed sodium salt.

A convenient method for the preparation of alkyl esters of 1-hydroxy phosphonic acid is the treatment of dialkyl hydrogen phosphite with aldehyde in presence of basic catalyst like sodium alkoxide[1,2] triethylamine[3] etc.

It has seen observed that the condensation of phenolic aldehyde with dialkyl-hydrogen phosphite takes place less readily by using sodium alkoxide, due to the formation of sodium salt. After condensation sodium salts were neutralised by suitable acid to obtain compounds in a pure state. On the other hand when aromatic aldehydes—aldehyde group connected with aromatic ring through aliphatic chain are condenced with dialkyl hydrogen phospites in presence of sodium methylate, a very vigorous reaction occurs.

In the present investigation, a series of new O-O-dialkyl 1-hydroxy phosphonates have been prepared by condensing 3-methoxy, 4-hydroxy-benzaldehyde and O-nitro cinnamicaldehyde with dimethyl, diethyl, dipropyl, diisopropyl, dibutyl, diisobutyl, diisoamyl, di-sec. amyl phosphites and characterised as detailed in the experiental part.

The catalyst employed in these condensations was sodium methylate (saturated). These compounds may be regarded as analogues of "Dipterax", which is a powerful insect poison and is effective against D. D. T. resistant houseflies.[4]

EXPERIMENTAL

Dialkyl hydrogen phosphites. These were prepared from phosphorus trichloride and corresponding alcohols by the method of H. Mc Combie, et al[5,6] using carbon tetrachloride as a solvent.

Substituted aldehydes:

O-nitro cinnamic aldehyde[7]. It was prepared by nitration of cinnamic aldehyde with concentrated nitric acid in presence of acetic anhydride and acetic acid at low temperature.

O-O dialkyl-1-hydroxy-(3-methoxy-4-hydroxy phenyl) phosphenates:

Equimolar quantities of 3-methoxy-4-hydroxy-benzaldehyde and phosphite were mixed together and briefly heated to dissolve 18 to 20 drops of sodium methoxide were added drop by drop with shaking. After half an hour, temperature of the contents was raised and maintained at 90° - 95°C for 60-70 minutes. After cooling, absolute ethanol was added and the reaction product was neutralised with hydrochloric acid, filtered and the filtrate was allowed to crystallize at room temperature.

The product was recrystallised from ethanol and their yield, properties and percentage of phosphorus are given in Table I.

TABLE 1

O, O dialkyl-α-hydroxy-(3-methoxy-4-hydroxy phenyl) phosphonates

No.	Dialkyl	Formulae (molecular)	% yield	Crystal form and colour	M. P. °C (uncorr.)	% Phosphorus	
						Fund	Calc.
1.	Dimethyl	$C_{10}H_{15}O_6P$	53 8	White needles	67·0	11·5	11·8
2.	Diethyl	$C_{12}H_{19}O_6P$	51·7	-do-	68·5	10·5	10·6
3.	Diisopropyl	$C_{14}H_{23}O_6P$	45·1	Dark white needles.	70·0	9·3	9·7
4.	Dipropyl	$C_{14}H_{23}O_6P$	48 4	Colourless needless	74-75	9·5	9·7
5.	Diisobutyl	$C_{16}H_{27}O_6P$	44·1	Dark white needles	71-72	9·7	8·9
6.	Dibutyl	$C_{16}H_{27}O_6P$	47·0	Colourless needles	77-78	8·6	8·9
7.	Diisoamyl	$C_{18}H_{31}O_6P$	30·0	-do-	65	8·1	8·2
8.	Di-Sec. Amyl	$C_{18}H_{31}O_6P$	32·4	Grey needles	62	7·9	8·2

O, O dialkyl-1-hydroxy-(O-nitro cinnamyl) Phosphonates.

$$CH = CH. CH (OH) \overset{\overset{\textstyle O}{\|}}{P} (OR)_2$$

[550]
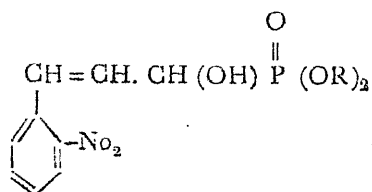
Equimolar quantities of O-nitro cinnamic aldehyde and phosphites were mixed and 15 drops of sodium methylate was added dropwise. A vigorous exothermic reaction occurred and moderate cooling was necessary. After 15 minutes temperature of the contents was maintained at 75°-80C for half an hour and left over night. Next day, the product was distilled under reduced pressure the red and liquid on keeping in frigidaire for fifteen days, deposited crystals, which were filtered, washed and recrystallised from alcohol.

The yield, properties and percentage of phosphorus as determined by Pregl[8] method are given in Table 2.

TABLE 2

O, O dialkyl-a-hydroxy-(O-nitro-cinnamyl) Phosphonates

No.	Dialkyl	Formulae (molecular)	% yield	State and colour	B. P. °C rom	M. P. °C (uncorr)	% Phosphorus	
							Found	Calc.
1.	Dimethyl	$C_{11}H_{14}O_6PN$	64·3	Red plates	185-90/6	73	10·4	10·8
2.	Diethyl	$C_{13}H_{18}O_6PN$	32·0	Red needles	—	64·5	9·6	9·8
3.	Diiso-propyl	$C_{15}H_{22}O_6PN$	58·3	Red plates	174-77/8	74	8·6	9·0
4.	Dipropyl	$C_{15}H_{22}O_6PN$	29·4	Reddish yellow plates	170-74/11	61	9·2	9·0
5.	Diiso-butyl	$C_{17}H_{26}O_6PN$	54·0	Reddish yellow plates	138-41/9	71	8·0	8·3
6.	Dibutyl	$C_{17}H_{26}O_6PN$	48·6	Golden plates	192/8	226-27	8·3	8·3
7.	Diiso-amyl	$C_{19}H_{30}O_6PN$	25·6	Colourless crystals	123-24/8	153-54	7·1	7·7
8.	Di-Sec. Amyl.	$C_{19}H_{30}O_6PN$	25·6	Red liquid	121-23/13	—	7·3	7·7

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KINETICS OF THE DARK REACTION BETWEEN OXALATE AND IODINE IN PRESENCE OF PERMANGANATE

By

H. L. KALRA* *and* S. GHOSH†

Chemical Laboratories, University of Allahabad, Allahabad

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ABSTRACT

The reaction between oxalate and aqueous iodine in dark has been found to be catalysed in the presence of small amounts of permanganate. The reaction velocity increases with the increase in the concentration of the permanganate, while H+ ions have depressing effect on the rate of reaction. The total order of the reaction is two, one each with respect to the oxidant and the reductant. A mechanism involving the formation of OH and C_2O_4—radicals has been suggested for the reaction.

The kinetics of the reaction between oxalate and iodine has extensively been studied, both in dark and in sunlight (1—3). The reaction in dark has a high temperature coefficient and is very slow at room temperatures. Dhar (2) and also Berthoud and Bellenot (4) reported that for the reaction in the dark, the rate is proportional to the concentration of oxalate and also to that of iodine, but is depressed by potassium iodide, with which iodine solutions are usually prepared. Hydrogen ions are also known to lower the reaction velocity.

The oxidation of oxalate by mercuric chloride has been well investigated as a photo-chemical process. Dhar (2) showed that the reduction of mercuric chloride to mercurous chloride may be brought about by the addition of small amounts of potassium permanganate, which itself is reduced and this type of reactions have been classed as induced reactions. In the present paper oxalate-iodine reaction has been investigated in the presence of very low concentrations of potassium permanganate as an inductor, using oxalate solutions at different pH. The effect of concentration of oxalate solutions and also that of permanganate on the rate of reaction have been investigated.

EXPERIMENTAL

Solutions of 0·01M potassium permanganate, 0·25M oxalic acid and 0·25M potassium oxalate were prepared using reagent grade chemicals. Iodine solution was prepared (in the absence of potassium iodide) by shaking crystals of iodine with water for about an hour and ca 0·002M solution could thus be obtained. Mixture of potassium oxalate and oxalic acid of the following compositions were prepared and the pH measured. The total concentration of the oxalate ion remained constant, while the hydrogen ion concentration in the reaction mixtures varied.

Present addresses :—

   * Department of Chemistry, Kurukshetra University, Kurukshetra.

   † Department of Chemistry, University of Jabalpur, Jabalpur.

TABLE 1

pH of Mixtures of Potassium Oxalate and Oxalic Acid

Solution	Mixture		pH
	0·25M Potassium oxalate (ml)	0·25M Oxalic acid (ml)	
A	98	2	5·27
B	90	10	4·48
C	80	20	4·10
D	60	40	3·38

Solutions of oxalate, potassium permanganate and iodine were maintained at a constant temperature before mixing. Measured volumes of potassium permanganate and iodine were added almost simultaneously to a constant volume of the oxalate solution.

The reactions were always carried out in Jena bottles coated from outside with black japan and further wrapped in black opaque linen to avoid the effect of light. In all the cases first order velocity constants have been calculated. The results are tabulated. The concentrations recorded in the table are final concentrations of the reactants in the reaction mixture.

TABLE 2

Effect of Concentration of Permanganate on the Rate of Reaction between Oxalate and Iodine

Oxalate = 0·1M (pH 5·27) ; Iodine = 0·00066 M ;
Temp. = 30°C

Permanganate	0·00002M	0·00003M	0·00004M	0·00008M
Time (min.)	$k/2\cdot303$ (min^{-1})	$k/2.303$ (min^{-1})	$k/2\cdot303$ (min^{-1})	$k/2\cdot303$ (min^{-1})
2	—	—	—	—
5	0·04440	0·05870	0·06470	0·08080
10	0·04107	0·05026	0·06335	0·07396
15	0·03697	0·04436	0·05052	0·07424
20	0·03610	0·04617	0·05091	—
25	0·03430	0·04661	0·05473	—
30	0·03471	0·04510	—	—

For comparison the reaction between oxalate and iodine in the absence of permanganate was also carried. The average value of k/2·303 was found to be 0·001078 min^{-1}.

[554]

TABLE 3

Effect of pH on the Rate of Reaction

Oxalate = 0·1 M ; Iodine = 0·00066M ; Permanganate = 0·00004M
Temp. = 30°C.

pH of the oxalate solution	Average $k/2·303$ min^{-1}
5·27	0·05684
4·48	0·04785
4·10	0·04051
3·38	0·02601

The order of reaction with respect to oxalate has been calculated from the relation

$$n = \frac{\log k_1/k_2}{\log 2}$$ where k_1 and k_2 are the average velocity constants for the two concentrations of the oxalate 0·1 M and 0·05 M respectively, and 'n' is the order of the reaction with respect to oxalate.

TABLE 4

Order of Reaction with Respect to Oxalate

Potassium permanganate = 0·00004 M ; Iodine = 0·00066 M
Temp. 30°C

pH of the oxalate solution	Average first order constants $k_1/2·303$ (min.$^{-1}$)	Average first order constants $k_2/2·303$ (min^{-1})	$n = \dfrac{\log(k_1/k_2)}{\log 2}$
5·27	0·05684	0·03079	0·90
4·48	0·04785	0·02702	0·82
4·10	0·04051	0·02437	0 73
		Average 'n' =	0·81

The order with respect to oxalate may be taken to be unity. Therefore, total order of the reaction is two.

DISCUSSION

The experimental results described in the paper conclusively show that the reaction between oxalate and aqueous iodine in dark is induced by the presence of very low concentrations of permanganate. Increase in the concentration of permanganate increases the rate of the reduction of iodine. On the other hand, increase in hydrogen ion concentration lowers the velocity of the reaction. The total order of the reaction is found to be two, unity with respect to iodine and also with respect to oxalate.

It has repeatedly been reported by various workers (5-3) that free radicals are produced in the course of reduction of Mn (VII) or Mn (III) by an oxalate solution. In the reduction of mercuric chloride by oxalate ion, in the presence of

permanganate, the reducing capacity of oxalate has been attributed by Weiss (9) and Abel (10) to the formation of $C_2O_4^-$ radicals (cf. Ghosh and coworkers-11) The generation of OH radicals is probably due to the action of water on higher valent manganese.

$$Mn^{+n} + H_2O \rightleftharpoons Mn^{+(n-1)} + H^+ + OH \quad \ldots\ldots(1)$$
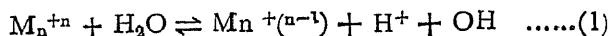
The reduction of permanganate to bivalent manganese is a five electron change and we may expect that OH radical will be formed at each stage of reduction. The radical OH is responsible for the formation of other active radicals by the interaction with the anion of the carboxylic acid

$$C_2O_4^{-2} + OH = C_2O_4^- + OH^- \quad \ldots\ldots\ldots(2)$$
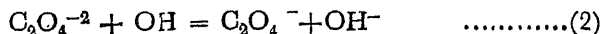
The $C_2O_4^-$ radicals then react with iodine according to the following steps :

$$I_2 + C_2O_4^- = I_2^- + 2 CO_2 \quad \ldots\ldots\ldots(3)$$

$$I_2^- + C_2O_4^{-2} = 2 I^- + C_2O_4^- \quad \ldots\ldots\ldots(4)$$
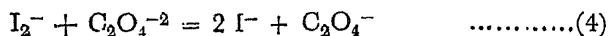
The $C_2O_4^-$ radicals produced in step (4) react with further iodine molecules and thus the chain is propagated.

Experimentally it has been observed (12) that permangnate is more efficient as an inductor than trivalent manganese. Step (1) indirectly supports this fact as the amount of OH radicals formed during the reduction of Mn (VII) to Mn (II) will be five times greater than the amount during the reduction of Mn (III) to Mn (II).

The rate determining step for the reduction of iodine is either equation (3) or equation (4). Equation (3) would indicate the reaction to be of the first order, while (4) would suggest the reaction to be of the second order as has experimentally been observed. Therefore, equation (4) is the rate determining step. Lowering in the rate of reduction of iodine with increasing acidity is explained by step (1) as the concentration of OH radicals is expected to decrease with the increase in acidity. Moreover, it is well known that hydrogen ions decrease the rate of reaction between oxalate and iodine.

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CHEMICAL EXAMINATION OF FRUIT COAT FAT OF THE SEEDS OF LITSEA-CONSIMILIS

By

D. R. GUPTA *and* S. K. GARG

Department of Chemistry, University of Roorkee, Roorkee (India)

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ABSTRACT

The fruit coat fat of the seeds of *litsea consimilis* has been chemically analysed. The fatty acid, composition was found to be capric acid, 4·51% ; lauric acid, 52·54% and oleic acid, 42·95%.

The seeds of a number of tropical plants belonging to lauraceae family have been reported to contain large quantities of fatty oils, some of which, besides being medically important,[1]) are of commercial interest as a source of excellent detergent, satisfactory lubricating agent for watches and other delicate machines and a wetting agent for insecticidal preprations. Amongst lauraceae plants, the seeds and fruit coat fats of *cinnamomum, litsea* and related genera have been thoroughly investigated by a number of workers[2,3,4,5]. Narang and Puntambekar[2] have chemically examined seed fats of a number of litsea species *i.e. L-chinensis, L-Zeylanica, L-citrata* and *L-launginosa* and found them to contain glycerides of lauric and oleic acids. *Litsea-consimilis*, another species of litsea, grows plentifully in Kumoan region. The oil from its berries is used by local people in the treatment of various skin diseases and is applied for healing wounds. This plant has not been investigated so far. It was, therefore, considered worthwhile to take up a systematic study of this plant. The amino acid make-up of the proteins isolated from the seeds was reported earlier[6]. In the present communication, the authors have reported their results on systematic study of fruit coat fat of *Litsea-consimilis*.

EXPERIMENTAL

The seed coat was removed mechanically from the seed kernels, powdered and soxhleted with petroleum ether (60-80°). A yellowish brown oil which solidified

completely at 15°C, was obtained in 16% yield. It was treated with Fuller's earth and activated charcoal. The purified oil, freed from volatile essential oil as far as possible by heating in *Vacuo*, had the following characteristics :

Specific gravity at 35°C, 0·9026 ; Refractive index at 40°C, 1·4565 ; Acid value, 74·46 ; Saponification value, 240·96 ; Ester value, 166·50 ; Iodine value (Hanus), 48·45 ; Acetyl value, 11·58, Hehner value, 93·10% ; R. M. value, 1·19 ; Polenske value, 1·02; Unsaponifiable matter, 1·98%.

The oil was saponified with alcoholic potassium hydroxide. The alcohol-free aqueous solution of the soap was thoroughly extracted with ether to remove unsaponifiable matter. The soap was treated with dilute sulphuric acid and the liberated fatty acids were extracted and examined in the usual manner. The mixed fatty acids possessed the following characteristics :---

Iodine value, 41-79 : Mean Molecular weight, 225·48.

The mixed fatty acids were separated into solid and liquid fatty acids using Hilditch's modification of Twitchell's lead salt method[7]. The liberated acids possessed the following characteristics.

		Solid acids.	Liquid acids.
Percentage	...	43·26	56·74
Iodine value	...	13·80	50·02
Mean molecular weight	...	219·90	224·49

The solid and liquid acids were esterified with methanol in the usual manner and the esters fractionally distilled under reduced pressure. The Iodine value, saponification equivalent and mean molecular weight of each fractions were determined and the composition of the esters calculated in the usual manner. The results are shown in Table No. 1 and II.

Characterization of the acids :—

The liquid ester fractions L_1-L_4 and the residue were saponified and the liberated acids on oxidation with dilute ice cold potassium permaganate solution gave a white crystalline solid which was characterised as dihydroxy stearic acid

TABLE I

Solid Esters Distilled at 9 mm.

Fraction No.	Temp./°C	Wt. gm.	I. V.	S. E.	Mean M. W.	Methyl esters	
						Laurate	oleate
S_1	90-100	3·8034	4·6468	214·95	214·196	3·5975	0·2059
S_2	100-110	2·9146	15·6035	228·40	229·728	2·3847	0·5299
S_3	110-120	2·3530	28·983	259·30	260·604	1·5583	0·7947
S_4	120-130	1·7736	37·840	266·69	270·07	0·9916	0·7820
Residue	...	1·0540	73·468	268·53	275·714	...	1·0540
Loss	...	0·0514	...	...	...	...	...
Total	...	11·9500	...	...	...	8·5321	3·3665

TABLE II

Liquid Esters Distilled at 10 mm.

Fraction No.	Temp./°C	Wt. gm.	I. V.	S. E.	Mean M. W.	Methyl esters		
						Caprate	Laurate	Oleate
L_1	120-130	3·1558	10·128	206·46	209·60	0·7909	1·9924	0·3725
L_2	130-140	3·5746	13·394	209·46	211·20	0·4367	2·5802	0·5577
L_3	140-150	4·0780	55·107	229·82	235·00	...	1·4592	2·6188
L_4	150-160	2·8382	89·661	278·04	277·14	...	...	2·8382
Residue	...	1·9248	89·080	280·47	281·43	...	...	1·9248
Loss	...	0·0102	...	...	...	...	...	...
Total	...	15·5816	...	...	...	1·2276	6·0318	8·3120

(M. P. 131°C ; M. W. 315), confirming the presence of oleic acid. The unoxidised portion was extracted with ether and the residue obtained after removal of ether was resolved into two fractions by treating it with 50% and 70% alcohol. These two fractions on recrystallization with 50% and 70% alcohol melted at 30°C and 43·5°C respectively, and were identified as capric acid M. P. 30°C, unchanged when mixed with pure capric acid), and lauric acid (M. P. 43·5°C unchanged when mixed with an authentic sample of lauric acid). The solid ester fractions S_1–S_4 and the residue were saponified and the liberated acids were oxidised with dilute alkaline potassium permagnate solution when dihydroxy stearic acid was obtained (M. P. 131°C ; M. W. 315), where as unoxidised portion on crystallization with 70% alcohol gave only lauric acid (M. P. 43·5°C).

The acids liberated from the corresponding solid and liquid ester fraction were also characterized by descending paper chromatographic technique[9].

In almost all fruit coat fats of lauraceae plants, palmitic acid has been reported to be present as the major saturated acid component except one case i. e. the fruit coat fat of Actinodaphne hookeri[9], which contains lauric acid (33%) as the major saturated acid component. It is however, quite interesting to observe that the major saturated acid component in the fruit coat fat of litsea-consimilis is lauric acid (52·54%). Moreover, the glyceride of capric acid, which does not occur in any fruit coat fat of lauraceae plants so far studied, has been found to be present in the fruit coat fat of litsea-consimilia.

Further work is in progress on the chemical examination of seed fat of litsea-consimilis.

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RELATIONSHIP BETWEEN EXCHANGEABLE SODIUM OF SALINE ALKALI SOILS AND CROP GROWTH*

By

J. S. P. YADAV

Senior Research Officer, Forest Research Institute, Dehra Dun

ABSTRACT

An investigation conducted on the cultivator's fields under each of paddy, jowar, wheat and barley crops in the district of Kanpur revealed that the amount of exchangeable sodium in the saline alkali soils has an inverse relationship with their growth response. The degree of calcareousness in the soil also has a depressing effect on the crop growth. Of all the crops studied, paddy showed greater tolerance to the alkali conditions for its normal growth. It is suggested that the determination of exchangable sodium percentage and calcareousness besides pH and electrical conductivity of the saturation extracts provides useful basis of evaluating the saline alkali soils for crop rating. Application of a suitable calcareous amendment to remove sodiun ions from the soil colloids is an essential pre-requisite for improving the productivity of alkali soils and achieving normal crop production.

Agricultural crops differ widely in their susceptibility to the degree of salinity and alkali. Depending upon the tolerance limits, a judicious selection of suitable crops mainly determines the success or failure of any cropping programme on the saline alkali soils. Although the study of salt tolerance of crops has received considerable attention in view of the vast areas occupied by these soils, the results have restricted applicability, since such tolerance limits vary with the local conditions of soil and climate. Breazeale (1926) opined that salt tolerance is the result of long adaptation of a plant to the conditions. The chief property of the alkali soils which affects plant growth is the presence in excessive concentration of soluble salts and exchangeable sodium. From his studies Collander (1941) concluded that "of all the ions sodium is the one most perfectly excluded by the plants". The inhibitory role of exchangeable sodium on plant growth by adversely affecting the physical condition and nutritional balance of the soil is considered to present a serious problem in agriculture. Ratner (1935), Singh and Chawla (1943), Thorne (1944), Bower and Wadleigh (1948), Hayward and Wadleigh (1949), Chang and Dregne (1955) and Bernstein and Pearson (1956) studied the influence of exchangeable sodium on the growth and nutrition of plants. Puri (1935) examined the relation between alkalisation and crop yields in Punjab.

The U. S. Salinity Laboratory (1954) had proposed a salinity scale to appraise the effect of soluble salts in the soil on crop growth. Since both salinity and alkali play an important role in affecting plant growth in the saline alkali soils of the Indian Gangetic alluvium, Agarwal and Yadav (1956) studied the combined effects of salt concentration and pH on the growth behaviour of common agricultural crops and evolved a salinity-eum-alkali scale for crop rating. This study was further extended to examine the relationship between the exchangeable sodium content in soils and crop growth and the results are reported in the present paper.

EXPERIMENTAL

Fifteen cultivators' fields representing various stages of salinity and alkali were selected at random in the district of Kanpur separately for each of paddy

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and jowar in *kharif* and wheat and barley in *rabi*, in which all stages of crop growth were available in contiguous plots. These fields were recently brought under the plough and did not receive any special treat nent for reclamation. The fields were visited for soil sampling when the crops were actually standing in an advanced state of maturation. Each field was divided into three contiguous plots such that each plot contained the crop in three stages of stand, *viz*, (1) uniformly normal stand, (2) stunted growth and (3) almost no survival at all, but the present investigation relates only to the two grades of crop growth namely, normal stand and almost no survival. In selecting the fields every care was taken to see that the factors other than salinity and alkali were not limiting crop growth and that the crop was sown uniformly and was given the same cultural and irrigation treatments over the entire field.

Surface soil samples were collected from beneath the active root zone of the growing crops from each of the above graded plots in every field and in each plot soil samples were obtained seperately from three different spots. Since the alkali soils of the Indian Gangetic alluvium are usually associated with the presence of calcium carbonate (Yadav and Agarwal 1963), determination of calcareousness was also included in the study. Agarwal and Yadav (1956) had earlier suggested that the degree of calcareousness should form one of the workable criteria for an appraisal of these saline alkali soils. The degree of calcareousness was estimated qualitatively by the use of dilute hydrochloric acid.

RESULTS AND DISCUSSION

Only average values of the triplicate estimates representing a particular growth level in each field have been reported in table 1 and 2. These average values give a fairly reliable assessment of the resultant effect of alkali on crop growth.

From table I it will be seen that the exchangeable sodium percentage in the soil complex has a profound influence on the growth of common agricultural crops. In case of paddy the best growth was witnessed at the exchangeable sodium content below 13·8 percent with an average value of 6·1 percent, while the growth was completely suppressed when the amount of exchangeable sodium exceeded the mean value of 52·4 percent although the adverse effect was noticeable even at the value of 24·7 percent. Jowar crop flourished well till the saturation percentage of sodium in the exchange complex was on an average below 2·3, though a value as high as 6·6 did not have any adverse effect. Its growth was almost entirely inhibited when the mean value of exchangeable sodium rose to 50·3 percent, but the deleterious effect was recorded even when the value increased above 16·6 percent. The growth of wheat crop was found quite satisfactory so long as the quantity of exchangeable sodium remained below 12·0 percent, but on the whole an amount below 3·0 percent appeared to be most favourable. The crop production tended to be impaired at a value over 14·7 percent and there was almost complete failure of the crop in areas where sodium saturated the absorbing complex to the extent of more than 51·5 percent. The barley crop grew normally on soils where the percentage saturation of sodium averaged to 3·7 and did not exceed 4·0, while the content greater than 22·9 percent caused serious damage and the crop failed to grow in soils in which the concentration of exchangeable sodium had risen in general higher than 55·4 percent.

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TABLE I

Exchangeable sodium percentage in soil and crop growth

Field no.	Paddy		Jowar		Wheat		Barley	
	Normal	Failure	Normal	Failure	Normal	Failure	Normal	Failure
1	5·9	52·5	0·6	62·3	0·4	37·6	3·0	29·1
2	0·6	60·4	0·6	46·6	7·9	25·4	0·9	22·9
3	0·5	33·9	Tr.	46·2	Tr.	47·2	2·0	80·7
4	Tr.	46·6	4·9	34·8	Tr.	52·9	0·6	32·5
5	1·6	67·4	0·5	45·3	1·6	30·2	14·0	38·4
6	0·4	47·8	0·2	61·4	9·1	45·5	0·1	39·8
7	2·6	24·7	0·9	42·0	Tr.	51·5	0·4	52·5
8	4·0	44·7	6·6	27·2	0·6	48·5	2·6	42·6
9	13·5	64·5	4·4	64·4	12·0	75·6	6·4	80·0
10	5·8	60·3	4·4	56·1	7·4	30·7	4·7	81·0
11	12·0	53·4	3·3	78·5	Tr.	94·4	3·9	92·8
12	10·7	68·1	3·6	62·2	0·4	29·0	4·4	73·8
13	13·8	58·7	2·5	30·7	Tr.	75·8	5·2	74·2
14	9·7	56·1	1·2	58·6	2·2	47·4	2·2	63·7
15	10·6	46·4	1·5	38·5	2·9	81·2	4·5	26·6
Average	6·1	52·4	2·3	50·3	3·0	51·5	3·7	55·4

Tr. = Traces

An examination of table 2 illustrates that like exchangeable sodium calcareousness in soil has also an inverse relationship with the growth status of agricultural crops. In general, the paddy crop could grow normally on slightly calcareous soils, and in some cases even on moderately to highly calcareous soils. On the whole, however, the soil portion where paddy crop failed to survive was most highly impregnated with calcareousness. The soils having normal growth of jowar crop were mostly non-calcareous, whereas the soils in which its growth was adversely affected displayed moderate to high calcareousness. An uniformly good growth of wheat was observed only in non-calcareous areas. The crop remained stunted even if slight calcareousness was present in the soil and failed almost completely in the soils where moderate to high intensity of calcareousness was met with. As in the case of other crops, calcareousness has a marked detrimental influence on the growth of barley crop as well. Non-calcareous soils were most favourable for the normal production of this crop and there was almost complate failure in soils which were moderate to highly calcareous. Nevertheless,

exact isolation of individual effect of calcareousness on crop growth is not possible with the present limited data, because calcareousness formed an integral part of the alkali soils examined. It is quite probable that the individual limits of calcareousness for varying crop growth will be much higher than those recorded here.

TABLE 2

Calcareousness in soil and crop growth

Field no.	Paddy		Jowar		Wheat		Barley	
	Normal	Failure	Normal	Failure	Normal	Failure	Normal	Failure
1	++	+++	+	+++	0	+	0	++
2	++	+++	0	+++	0	++	0	+
3	0	+	0	++	0	+++	0	++
4	0	+++	0	++	0	++	0	++
5	+	+++	+	++	0	+	0	++
6	0	+++	++	+++	0	++	0	+++
7	++	+++	0	+++	0	++	0	++
8	+++	+++	0	+	0	++	0	++
9	+++	+++	0	+	0	+	0	+
10	+	+++	0	++	0	+	0	+
11	0	++	0	+	0	++	0	+
12	0	++	0	+	0	+	0	+
13	+	++	0	+	0	+	0	+++
14	+	+++	0	++	0	+	0	++
15	+	++	0	+++	0	+	0	+++
Average	+	+++	0	++	0	++	0	++

0 = Nil, + = Slight, ++ = Moderate, +++ = High

The foregoing data reveal that the presence of both exchangeable sodium and calcareousness in soil is negatively correlated with the growth response of the agricultural crops. Magistad (1945) observed that the amount of exchangeable sodium greater than 12 percent causes deterioration of the physical properties of soil and has a depressing effect on plant growth. Ratner (1935) stated that exchangeable sodium to the extent of 50 percent becomes injurious to plant growth, whereas Thorne and Peterson (1954) fixed this limit at 15 to 20 percent. In the present investigation there was degradation in the growth quality with an increase in the exchangeable sodium content above about 6 percent and a

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saturation by sodium over 50 percent of the cation exchange capacity resulted invariably in almost complete mortality of the crops. Of the four crops studied, paddy and jowar exhibited the highest and lowest tolerance to the amount of exchangeable sodium for their normal growth. The work of Bower and Turk (1946), Stanberry (1948), and Shawarbi (1950) indicates that apart from an adverse effect on the physical properties of soil a nutritional disturbance in the alkali soils leads to poor plant growth, while Greaves and Jones (1941) attributed the effect of alkali on the microbiological activities for such inhibited growth. Basu & Tagare (1943) noticed a lower status of available potash and phosphoric acid as well as microbial activity in alkali soils. As the effect of exchangeable sodium is modified by such factors as salt content, texture, induration of subsoil, presence of concretions and pan, depth of water table, etc., it is desirable to take them into account side by side while evaluating the alkali soils for crop rating and deciding management practices. The effect of texture, salt content and pH on crop growth was examined in detail by Agarwal and Yadav (1956).

Although calcareousness has a depressing effect on the growth of all crops, paddy was found to be capable of growing normally even in slightly calcareous soils and was thus relatively more tolerant of calcareousness than the other crops which manifested normal growth only in the non-calcareous soils. This provides a convincing evidence that paddy is able to tolerate more adverse conditions of alkali soils and should therefore be given first choice in the cropping programme for the saline alkali soils. In view of such significant differences in the tolerance limits and different cultural practices required, Agarwal and Yadav (1956) had proposed a slightly different salinity-cum-alkali scale for paddy. The greater capacity of paddy crop to tolerate alkali conditions has obviously led to its more wide-spread use as a reclaimant crop for the alkali lands. Paddy was found to be an efficient crop in the reclamation of saline alkali soils by Yadav and Agarwal (1959 and 1961).

It is concluded that the determination of exchangeable sodium and calcareousness besides pH and electrical conductivity of saturation extracts provides useful basis of evaluating the saline alkali soils for crop responses. Addition of a calcareous amendment like gypsum supplemented with organic manure and adequate drainage appears to be an essential requirement for promoting the productivity of alkali lands and for achieving normal crop growth. The essentiality of adding sufficient quantity of soluble calcium for replacing sodium ions from the absorbing complex apart from adequate provision for washing out soluble salts has been stressed by Sigmond (1932), Yadav and Agarwal (1959) and several other workers. Calcium carbonate which is present as an integral part in these soils may also play a vital role in their reclamation if rendered soluble.

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RELATIONSHIP BETWEEN THE SOLAR AND MAGNETIC PHENOMENA WITH COSMIC-RAY INTENSITY

R. S. YADAV

Department of Physics, A. M. University, Aligarh

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ABSTRACT

The paper discusses the effect of the Solar flares of importance 1 and 2 and the magnetic storms following them on Cosmic-ray meson intensity, recorded at Ottawa ($\lambda = 57°N$), Churchill ($\lambda = 70°N$) and Resolute ($\lambda = 83°N$) during 1957-58, following the supperimposed epoch method of Chree.

88 cases of Solar flares are considered and it is found that there is no increase in meson intensity at any station. But a decrease in meson intensity which is associated with the M-storms following the flares, is observed after a few days from the flare day (or zero day) at all the stations. This decrease is large during the period of large solar activity.

The average time interval, $\triangle t$, between the solar flares and the start of the subsequent geomagnetic storms is slightly greater than one day.

1. INTRODUCTION

Newton[1] has reported that the solar flares are almost followed by geomagnetic storms in less than 2 days. Dodson and Hedeman[2] studied 115 cases of the Solar flares and found that the flares were frequently followed by the geomanetic storms within one to four days.

In this paper the effect of Solar flares and magnetic storms phenomenon, has been studied, on Cosmic-ray meson intensity observed at high latitude stations, Ottawa ($\lambda = 57°N$), Churchill ($\lambda = 70°N$) and Resolute ($\lambda = 83°N$), as the effect is more pronounced at higher latitudes. Therefore it is easier to detect the increases associated with smaller solar flares.

Eighty eight cases of Solar flares of all importance reported by the Astrophysical observatory, Kodaikanal and Nizamiah observatory, Hyderabad (India) during July, 1957 to September, 1958 were studied. In order to study the effect of these flares in detail at three stations the following points were kept in view.

(1) Relationship with latitude *i. e.* how the Cosmic-ray intensity is affected at different latitudes by Solar flares and magnetic storms following them.

(2) The effect of solar flares of different importance on Cosmic-ray intensity.

(3) The effect on Cosmic-ray intensity of those solar flares which are followed by magnetic-storms and also of those which are not followed by Magnetic-storms.

(4) Associations between the solar phenomena and the subsequent geomagnetic effects which are studied by considering the values of the geomagnetic indices C_p using the supperimposed epoch method of Chree[3].

The data of geomagnetic storms which has been used here is taken from J. Geophysical Res. 1957 and 1958. The values of C_p for 1957 are taken from the data published in J. Geophys. Res. 1957-58. For 1958 the values of C_p are taken from the data supplied by D. J. Bartles Zurich Observatory, Switzerland.

2. RESULTS

The effect of the Solar flares of all the importance, reported during the period 1957-58, on pressure corrected meson intensity recorded at Ottawa ($\lambda = 57^\circ N$) has been examined. The results are shown in table 1 (a).

TABLE 1 (a) Ottawa

($\lambda = 57^\circ N$)

Period	(July to Dec.) 1957	1957-58	(Jan to Aug.) 1958
Sun spot Numbers.	212·3	199·5	186·6
Percentage decrease from mean at dip.	−0·26% ± 0·044%	−0·18% ± 0·034%	0·12% ± 0·046%
Dip day after the zero day.	2nd day.	2nd day	2nd day.

To observe the effect of Solar flares on meson intensity during the time of different solar activity, the period 1957-58 has been divided into two groups. The first group extends from July to December, 1957 and the second group from Jan. to August, 1958. The I_m (Daily mean meson intensity) records of Ottawa have been analysed for these two groups separately and the results obtained are shown in table 1 (1) and figure 1.

FIG 1
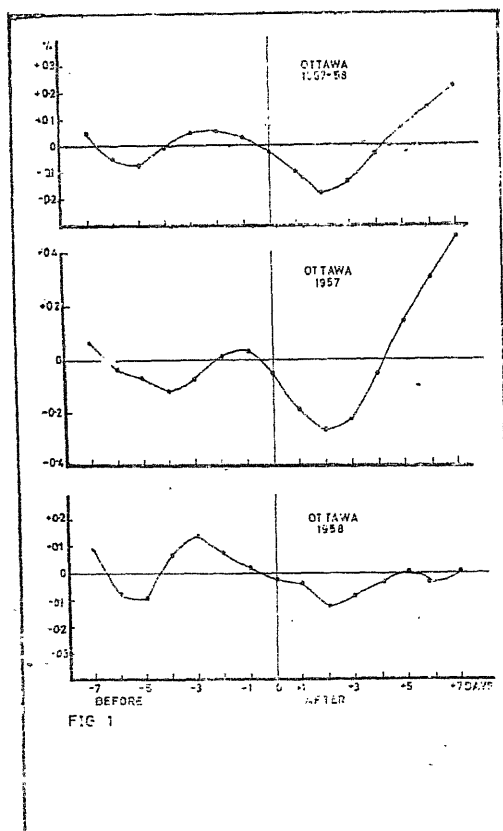
The latitude dependence of the effect of Solar flares on meson intensity has been examined by analysing the meson intensity data for three stations Ottawa ($\lambda = 57^\circ N$), Churchill ($\lambda = 70^\circ N$) and Resolute ($\lambda = 83^\circ N$). The results obtained are shown in figure 2.
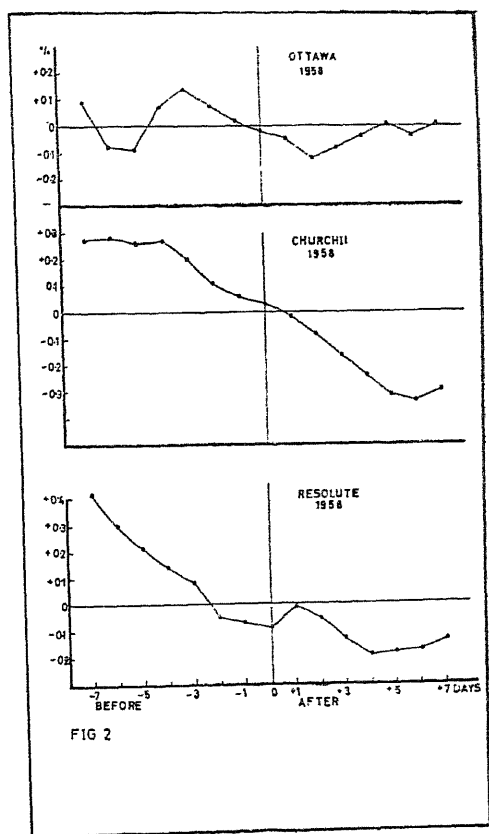
FIG 2

From the figure 1, it is clear that for the period 1957-58 there is a dip (denoting a percentage decrease of I_m from average) of magnitude $- 0.18\%$ $\pm .034\%$ from the average at second day after the flare day (or zero day) at Ottawa.

For both the groups 1957 and 1958, the dip occurs at the second day after the flare day at Ottawa, but the magnitudes of the dip for the groups 1957 and 1958 are $- 0.26\% \pm 0.044\%$ and $0.12\% \pm 0.046\%$ respectively. Hence the magnitude of the decrease at the dip is larger during the group 1957 (which is the year of greater solar activity as compared to 1958) than that of 1958 group.

From the table 1 (b) and figure 2, it is clear that the time of occurrence of the dip and its magnitude do not show any systematic relationship with geomagnetic latitudes.

TABLE 1 (b)

Period	Station	Ottawa	Churchil	Resolute
	Geomagnetic Latitude.	57°N	70°N	83°N
1958 {	Percentage decrease form mean at dip.	$-0.12\%\pm0.046\%$	$-0.33\%\pm0.044\%$	$-0.19\%\pm0.044\%$
	Dip day after the zero day.	2nd day	6th day	4th day

3. ASSOCIATION BETWEEN THE DAILY MEAN MESON INTENSITY AND IMPORTANCE OF SOLAR FLARES

To see the association between the importance of the Solar flares and the Cosmic-ray intensity in detail, 88 cases of solar flares are divided into two groups. The first group contains 14 solar flares of importance 2, observed during 1957-58 and the second group contains 72 flares of importance 1. There are also two flares of importance 3, but on account of their poor number they are not considered here in a separate group. The results are shown in figure 3.

FIG.·3
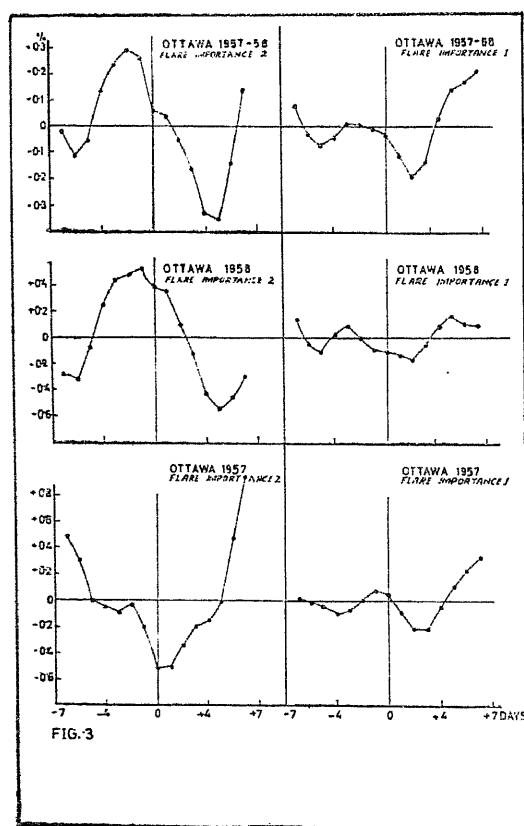
Separate study for the year 1957 and 1958 is also performed and the flares during these years are also grouped according to their importance separately. The statistics of the flares according to the groups for the year 1957 and 1958 are given in the table 2, and the results are shown in the figure 3.

TABLE 2

Ottawa (Station)

Period	Group	Number of Solar flares	Importance of flares
1957-58	Gr. I.	14	2
	Gr. II.	72	1
1958	Gr. I.	9	2
	Gr. II.	37	1
1957	Gr. I.	5	2
	Gr. II	35	1

The fig. 3 shows that during the period 1957-58 the dip in the first group lies on the 5th day after the flare day (zero day), and its magnitude is $-0.35\%\pm0.085\%$ below average. In the second group the dip occure at the second day after the flare day and its magnitude is $-0.19\%\pm0.037\%$.

During the year 1958, the dip in case of Solar flares of importance 2 (gr. 1) occurs at the 5th day after the flare day and its magnitude is $-0.54\%\pm0.106\%$. In case of the Solar flares of importance 1 (gr. 2), the dip occurs on the 2nd day after the flare day and its magnitude is $-0.16\%\pm0.052\%$ (decrease from average).

In the year 1957, the behaviour of the daily mean meson intensity is different as compared to the year 1958. In this year the dip occurs at the zero day for the group I and its magnitude is $-0.52\%\pm0.144\%$. In case of the Group 2, the dip occurs at the 3rd day after the flare day and its magnitude is $-0.22\%\pm0.054\%$

[571]

These results are summarized in table 3, and the following conclusions can be drawn: —

TABLE 3

Ottawa ($\lambda = 57^\circ N$)

Period	Group	Group I	Group II	Sunspot numbers
	Importance of flares	2	1	
1957-58.	Percentage Degrease from mean at dip.	$-0.35 \pm 0.085\%$	$-0.19 \pm 0.037\%$	199.5
	Occurrence of the dip after the flare day	5th day	2nd day.	
1958	Percentage decrease from mean at dip.	$-0.54 \pm 0.106\%$	$-0.16 \pm 0.052\%$	186.6
	Occurrence of the dip after the flare day.	5th day	2nd day.	
1957	Percentage decrease from mean at dip.	$-0.52 \pm 0.144\%$	(i) $- 0.22$ (ii) $- 0.21$ } $+0.054$	212.3
	Occurrence of the dip.	Zero day (i. e. on flare day).	(i) 3rd day. (ii) 2nd day.	

(1) During the years 1957-58, 1958 and 1957, which represet the years of different solar activity, it is found that the decrease of meson intensity at the dip is larger in case of the solar flares of importance 2 (gr. 1) than in case of the flares of importance 1 (gr. 2).

(2) From the sunspot numbers which represent the solar activity, it is clear that the year 1957 is of greater solar activity than the year 1958.

Hence it is clear that in case of the solar flares of importance 1 (group 2), the decrease of meson intensity at the dip is larger during the larger solar activity (i. e., in the year 1957) or in other words the decrease at the dip increases as the solar activity increases in different years. But this sort of conclusion can not be drawn from the group 1, which represents the flares of importance 2, because of the poor statistics of the flares in this group as compared to the group 2.

(3) During the year 1957 for group 2, the decrease on 2nd and 3rd day after the flare day is almost of the same magnitude. Hence it can be said that during all the years of different solar activity the time of occurrence of the dip is the same in case of flares of importance 1 (i. e., gr. 2.). Similar conclusion is however, not possible in group 1 due to the poor Statistics of flares.

[572]

4. ASSOCIATION BETWEEN THE DAILY MEAN MESON INTENSITY AND SOLAR FLARES FOLLOWED AND NOT FOLLOWED BY MAGNETIC-STORMS

The meson intensity and Ottawa is again examined from another point of view discussed below:—

All the 88 cases of flares during the year 1957-58 are divided into two groups A and B. Group A contains those flares which are not followed by M-storms and group B contains those flares which are not followed by M-storms.

If the time interval, Δt, between the occurrence of Solar flare and the magnetic-storms is $\leqslant 5$ days, then that particular flare is considered to be followed by M-storms and is put in the group A. If $\Delta t > 5$ days the flare is considered to be not followed by M-Storm and is put in the group B. This way 78 flares are followed by the M-storms and the rest 10 are not.

The results obtained are shown in the figure 4. For the flares which are not followed by the M-storms no appreciable decrease from the average is observed. The curve for the flares followed by M-storms shows a decrease of meson intensity which starts from zero day and reaches the maximum value on 2nd day after the flare day and remains at this level upto the 3rd day and then starts increasing. The magnitude of the decrease is $0.24\% \pm 0.036\%$.

FIG. 4

AVERAGE SUPERPOSED VALUES OF Im FOR 7 DAYS BEFORE AND AFTER FLARES WHICH ARE FOLLOWED BY M-STORMS FOR THE PERIOD 1957-58
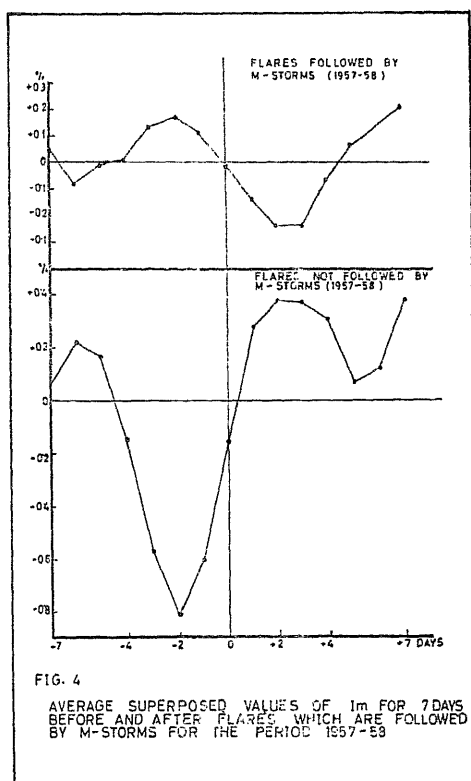
Hogg[4] also considered the cases of solar flares of larger importance (importance 2 and 3), but he did not find any remarkable increase both in case of flare followed by M-storms and in case of flares not followed by M-storms. Hoggs[4] found in case of flares accompanied by M-storms a significant decrease in cosmic-ray intensity for the second day after the flare-day. In our case also there is a decrease of magnitude $-0.24\% \pm 0.036\%$ the 2nd day (persisting upto 3rd day) after the flare day, in case of flares accompanied by M-storms. Thus our results are in accordance with Hogg's results.

5. RELATION BETWEEN SOLAR FLARES AND GEOMAGNETIC DISTURBANCES:

The relationship between the flares and geomagnetic effects is studied by the Chree method, considering the geomagnetic indices C_p for the days before and after the flare events. The relationship between C_p and solar flares of importance 2 (9 cases) and importance 1 (37 cases) were examined separately for the period Jan. to Aug., 1958 and the results are shown in figure 5.

FIG 5

RELATION BETWEEN THE SOLAR FLARE AND GEOMAGNETIC DISTURBANCES
(i) CURVES A & B REPRESENT THE RELATION BETWEEN SUPERPOSED VALUES OF C_p AND SOLAR FLARE OF IMPORTANCE 1 AND 2 RESPECTIVELY
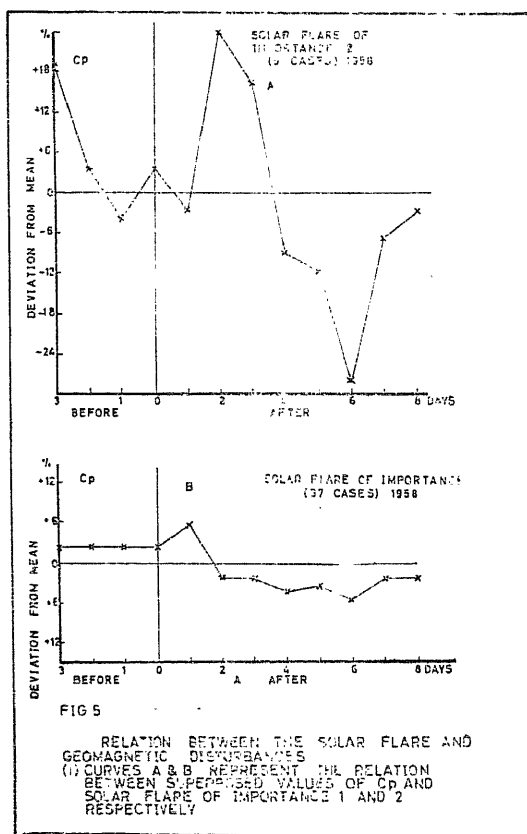
In case of the flares of importance 2, the average supperimposed value $(in\%)$ for C_p show a large increase starting from the first day after the flare day and reaching the peak value on the 2nd day followed the flare day. In case of flares of importance 1, the average supperimposed value of C_p $(in\%)$ starts increasing on the zero day and shows a peak value on the first day after the flare day.

The magnitude of increase for the peak value of C_p is quite large in case of flares of importance 2 than flares of importance 1. $\triangle t$ (time of interval) is also larger in the former case as compared to the later case.

Since the former case is based only on 9 cases, hence nothing can be said very definitely on the comparision basis between the two cases. But it is certain that there is an increase in C_p, which represents the geomagnetic disturbances, after the solar flares.

This sort of relationship was also observed by Dodson and Hedeman[2] considering the soldar flares of all importance during the period from Jan. 1949 to April, 1956 (115 cases). Denisse[5] and Simon[6] have also examined this sort of relationship.

6. THE INTERVAL, $\triangle t$, BETWEEN THE OCCURRENCE OF SOLAR FLARE AND THE START OF GEOMAGNETIC STORMS

The statistical details about $\triangle t$ and the solar flares are given in table 4.

TABLE 4

Period	$\triangle t$	Number of cases of Solar flares (f)	Percentage of number of cases
	0	35	45%
	1	20	26%
1957-58	2	10	13%
	3	7	9%
	4	3	4%
	5	3	4%
	$1^{d}.5^{h}$ average	78 Total No. of flares.	

[575]

• The average time interval, in our case is $\triangle t = 1^{d} {}_{3}^{h}$. The frequency distribution
• between $\triangle t$ and solar flares is shown in figure 6.

FIG.6

FREQUENCY DISTRIBUTION BETWEEN
$\triangle t$ AND SOLAR FLARES
$\triangle t$ REPRESENTS THE TIME INTERVAL
BETWEEN THE SOLAR FLARE AND START
OF GEOMAGNETIC STORM
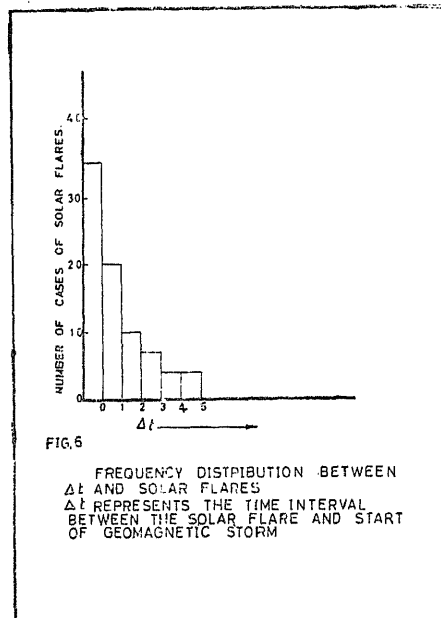
   In table 4, $\triangle t$ is calculated in unit of a whole day (difference in calender's dates) rather than in the exact time interval in hours between the start of flares and storms.

7. DISCUSSION AND CONCLUSIONS

   The decreases of meson intensity discussed here are the cumulative effect of the individual decreases of the Forbush-type. It is seen that most of the solar flares are followed by magnetic storms.

   Thus the Cosmic-ray decrease observed at the days after the zero day (or flare day), in a group in which only those flares are considered which are followed by magnetic storms, shows the possibility of existing a correlation between the cosmic-ray decreases and magnetic storms following the solar flares. This fact shows that the magnetic-storms and Forbush type Cosmic-ray decreases have a common cause.

   The study of the effect of magnetic storms, following the solar flares, on Cosmic-ray meson intensity reveals the following points:—

   (1) The percentage decrease of meson intensity at the dip is larger during the year of greater solar activity than the year of comparatively less solar activity as denoted by the sunspot numbers.

[576]

(2) During the year of greater solar activity (*i. e.* the year 1957), it is clear that the decrease of meson intensity at the dip is larger for the first group (containing flares of importance 2) as compared with the second group of flares of importance 1.

(3) There is no appreciable decrease of meson intensity for a group having flares not followed by M-storms but an appreciable decrease occurs at the dip in a group containing solar flares followed by M-storms.

(4) From the group study it is seen that the value of 'Δt' is smaller in case of the solar flares of larger importance. This is in agreement with the results of Dodson and Hedeman[2].

(5) An increase is observed in case of C_q values after the flare day. This increase is large in case of flares of larger importance.

(6) The above discussed percentage decreases of meson intensity at the dip are associated with geomagnetic-storms following the solar flares.

(7) The magnitude of the decrease at the dip and its time of occurrence do not show any systematic relationship with latitudes.

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AMINO DERIVATIVES OF ALUMINIUM CHLORIDE

By

SARJU PRASAD *and* NARAYANI PRASAD SINGH

Chemical Laboratories, Banaras Hindu University, Varanasi-5

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ABSTRACT

Compounds of aluminium chloride with diamines and secondary and tertiary amines have been prepared in benzene medium, their properties studied and structures discussed.

According to Sidgwick[1] aluminium chloride forms coordination compounds with ammonia and organic amines with great ease. Klemm[2,3] and coworkers observed that aluminium chloride forms a number of coordination compounds with ammonia, the most stable being the mono- and triammines, the former being a covalent compound of the type $Cl_3Al \leftarrow NH_3$ and the latter presumable a salt. Halske[4], Rose[5] and Band[6] prepared the compound $AlCl_3.NH_3$, Stillman[7,8] the compounds $AlCl_3.2NH_3$ and $AlCl_3.6NH_3$ and Yuju Shibata, Kurajo Fukajawa and Jan Asado[9]. the complex compound $Al(NH_3)_6Cl_3$ and studied its absorption spectra. Goubeau and H. Siebert[10,11] studied the Raman spectra of $AlCl_3.NH_3$ in molten condition and also prepared the addition compounds of aluminium chloride with methyl, ethyl, propyl, butyl, dimethyl and trimethyl amines. Dyke and Crawford[12] observed that $AlCl_3$ and $AlBr_3$ form 2:1 complexes with $(CH_3)_3N$ and $(CH_3)_2O$. Eley and Wotts[13] prepared aluminium halide complexes with pyridine, trimethyl and triethyl amines. B. Ya Rabinovich and A. G. Ponomarenko[14] obtained crystalline compounds $Al_2Cl_6.3CH_3CONH_2$ and $Al_2Cl_6.3CO(NH_2)_2$ with acetamide and urea respectively.

A general survey of the literature shows that practically no work has been done on the formation of compounds of aluminium chloride with amines. The present investigation was undertaken with a view to study the formation of complex compounds of aluminium chloride with diamines and secondary and tertiary amines.

EXPERIMENTAL

All the chemicals used were of B. D. H. or Merck's 'extra pure' quality.

Pure anhydrous aluminium chloride and amines were dissolved in benzene separately. The amine solution was added to the aluminium chloride solution till the precipitation is complete. It was filtered and the compound washed with benzene till free from the amine. The compound was dried and analysed.

Analysis :—

Aluminium was estimated as Al_2O_3 and chlorine as $AgCl$ by Piria and Schiffs method. In a few cases nitrogen was estimated by Duma's method, and the percentage of organic matter calculated; in the rest it was found by difference.

TABLE

S. No.	Amines	Probable formula	Colour	Dec. point	% Aluminium		% Chlorine		% Nitrogen		% Organic matter	
					Found	Calc.	Found	Calc.	Found	Calc.	Found	Calc.
1.	Benzidine	$Al_2Cl_6(NH_2C_6H_4C_6H_4NH_2)_2$	Ash	224°	8·123	8·498	33·85	33·55	8·65	8·82	56·83	57·94
2.	o-Dianisidiene	$Al_2Cl_6(CH_3ONH_2C_6H_3CH_3ONH_2C_6H_3)_2$	Pink	174°	7·211	7·264	29·47	28·67	7·31	7·42	63·69	64·07
3.	o-Phenylenediamine	$Al_2Cl_6(NH_2C_6H_4NH_2)_2$	Rosy red	260°	11·19	11·18	44·32	44·11	11·23	11·60	43·30	44·72
4.	m- ,,	,,	Black	151°	11·31	11·18	44·58	44·11	—	—	44·11	44·72
5.	p- ,,	,,	Chacolate brown	225°	11·11	11·18	44·61	44·11	—	—	44·28	44·72
6.	o-Tolidine	$Al_2Cl_6(NH_2CH_3C_6H_3C_6H_3CH_3NH_2)_2$	White	183°	7·153	7·381	29·50	29·14	—	—	63·34	63·48
7.	Diphenylamine	$Al_2Cl_6(C_6H_5NHC_6H_5)_3$	Brownish black	253°	9·20	8·92	35·50	35·22	4·45	4·63	53·73	55·85
8.	Methylaniline	$Al_2Cl_6(C_6H_5NHCH_3)_3$	Deep green	173°	10·88	11·22	44·51	44·29	—	—	44·61	44·49
9.	Ethylaniline	$Al_2Cl_6(C_6H_5NHC_2H_5)_3$	Light ,,	198°	10·99	10·60	42·10	41·85	—	—	46·91	47·54
10.	Benzylaniline	$Al_2Cl_6(C_6H_5NHC_6H_5CH_2)_2$	White	210°	8·504	8·525	33·29	32·65	4·28	4·42	55·95	57·82
11.	Diethylaniline	$Al_2Cl_6[(C_2H_5)_2NC_6H_5]_2$	Yellowish brown	231°	9·285	9·552	37·87	37·70	—	—	52·84	52·74
12.	Dimethylaniline	$Al_2Cl_6[(CH_3)_2NC_6H_5]_2$	Black	196°	10·81	10·60	42·24	41·85	5·38	5·50	46·55	47·54

GENERAL PROPERTIES

All the compounds are coloured, generally insoluble in organic solvents like alcohol, benzene, carbon tetrachloride and ethyl acetate, except a few which are sparingly soluble in alcohol. When heated they decompose without melting The compounds are stable at the room temperature in dry atmosphere but hydrolyse when brought in contact with water. The compounds obtainted with secondary and tertiary amines are comparatively less stable than those with diamines.

DISCUSSION

$AlCl_3$ forms compounds with diamines and secondary and tertiary amines in the ratio of 1:1. The compounds obtained with diamines are fairly stable which is probably due to symmetrical structure and chelation. They may be represented as
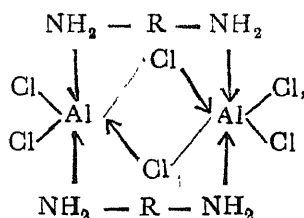
in which the maximum coordination number of aluminium *i.e.* 6 is attained. It is further supported by the fact that aluminium chloride exists in a dimeric form in benzene solution.

In the case of secondary and tertiary amines one molecule of aluminium chloride combines with one molecule of the organic substance, which is probably due to the weak coordinating power of $=NH$ and $\equiv N$ groups. Also the compounds are much less stable than those obtained with diamines.

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ELECTRO-CHEMICAL PROPERTIES OF IMPORTANCE IN ASSESSING THE ALKALI CONDITION OF SOILS

By

K. G. CHAUDHRI *and* B, RAMAMOORTHY

Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi-12

ABSTRACT

It has been found that the electro-osmotic velocity is a better measure of the alkali conditions in the soil as measured by its degree of dispersion than either the pH or the degree of sodium saturation. The poor coefficient of correlation between the degree of dispersion and degree of sodium saturation seemed to be due to the presence of high amount of organic matter which appears to cause greater dispersion in montmorillonitic soils and less dispersion in kalinitic and illitic soils. The low correlation coefficient between pH and the degree of dispersion seems similarily to be due to a greater dispersal than normal in montmorilliontic and less dispersion in illitic soils of the same pH.

On the problem soils called the alkali soils, the deterioration of the physical condition of the soils is caused primarily by the dispersion of clays which is now attributed to the presence of exchangeable sodium to an unfavourable extent. The degree of sodium saturation of the clay-complex is, therefore, usually taken as a measure of this condition. The U. S. A. salinity Laboratory (1954) reports that the limit for the degree of sodium saturation to be taken to characterise the formation of alkali soils varies with the type of soil. Thus the degree of sodium saturation, is not a safe measure for the degree of dispersion of all soil clays even when the soluble salts are removed from the soils. It has been suggesteds that zeta-potential of the soil clays determines the extent of dispersion of the clays. If this was so, the electro-osmotic velocity of the soil, which is related to the zeta poten tial, should bear a more direct relationship with the degree of dispersion than the degree of sodium saturation. The object of this investigation is to determine the relative correlation of the degree of dispersion of soils freed from the salts with the electro-osmotic velocity on one hand, and with the degree of sodium saturation on the other, as well as the pH of the soils which is also generally considered to be related to the dispersion of soils.

MATERIAL AND METHODS

Nine soils from different places, representing different types, which were equilibrated with the same solution containing calcium and sodium in the equivalent ratio of 1 : 1 and which were taken up for this study are described belo :

TABLE I

S. No.	Soil Description	pH of original soil	Soil Texture	Clay mineralogical composition
1.	Good alluvial soil from I. A. R. I. sub-station Karnal, Block 7, Plot 12	8·1	Clay loam	I
2.	Bad alluvial soil from I. A. R. I., sub-station Karnal, Block 7, Plot 8	9·65	Clay loam	I
3.	Good alluvial soil from I. A. R. I., sub-station Karnal, Block 7, Plot 8	9·70	Clay	I
4.	Cinchona brown forest soil from Mansong (West Bengal)	4·50	Clay loam	M+K
5.	Red fallow Soil from Belgaum	6·30	Clay	K + M
6.	Alluvial Soil from IARI farm, N. Delhi	8·30	loam	I + M
7.	Alluvial Soil from I. A. R. I. farm, middle Block.	8·10	loam	I+M
8.	Black Soil from Nagpur Agricultural farm.	7·90	Clay	M
9.	Black Soil from Padagaon alkali soil A phase, B. Type on the N. B. R. Canal.	9·0	Clay	M

I = Illite, M. Montmorillonite, K. Kaolinite.

METHODS

1. Determination of pH: The Bechman pH meter using glass electrodes was used for this purpose, with a soil to water ratio of 1: 2. 5.

2. Determination of degree of dispersion: Soil samples passed through 60 mesh sieve were shaken mechanically for half an hour with water 25 times their weight, and then diluted further 75 times and kept overnight. Next day, the water dispersible clay content was determined by the pipette method of the mechanical analysis in this suspension.

3. Electro-Osmotic velocity E. O. V. was determined by the method of Briggs, Bannet and Pierson, as used by Raychaudhri and Ghani (1942) The mobilities were measured at 30°C, applying 100 volts D. C.

4. The degree of dispersion D. D. was expressed in terms of the above as a percentage of the clay obtained by the International method of mechanical analysis in the same soil sample.

5. Exchangeable sodium was determined by leaching the soil with normal ammoniam acetate solution, after previously freeing it from the soluble

salts with alcohol. The sodium in the leachate was determined with the help of Perkin Elmers flame photometer using lithium as the internal standard. The degree of sodium saturation D. S. S. was found by determining exchangeable sodium as a percentage of cation exchange capacity, determined by the method of Piper (1950).

6. Determination of organic matter was made according to Bear (1954).

RESULTS AND DISCUSSION

The properties of various types of soils equilibrated with the same solution of a sodium adsorption ratio of 31·6, containing equal proportions of calcium and sodium (N/2 each as acetate and chloride respectively are given in Table II).

TABLE II

S. No.	Sample	pH	W. D. Clay %	D. D.	E. O. V. 5 mts. in cms.	C. Ex. Cap. me. 100 gms.	Ex. Na m. e. 100 gms.	Degree of Na satu- rations	Organic C%
1.	Karnal good	9·3	5·06	13·9	1·25	10·2	7·22	70·78	1·02
2.	Karnal bad	9·1	4·03	14·1	1·08	16·2	5·08	31·36	0·61
3.	Karnal M	9·25	8·81	21·8	1·20	9·0	6·40	71·11	0·24
4.	Cinchona	7·80	1·98	6·3	1·05	29·0	7·00	24·14	4·93
5.	Red Soil	7·95	2·52	4·1	0·85	17·0	9·21	52·40	3·07
6.	Delhi A	9·4	4·94	24·0	1·40	11·6	6·60	57·00	0·85
7.	Delhi AIM	9·4	3·30	16·3	1·25	13·4	6·60	49 28	0·57
8.	Nagpur Black soil	8·3	17·87	26·1	1·35	59·0	15·52	26·30	1·34
9.	Padagaon	8·4	13·32	18·9	1·20	51·6	15·00	29·08	1·53

The coefficient of correlation of the degree of dispersion of the soil was 0·502 with pH, and 0·0877 with the degree of sodium saturation both of which were not statistically significant.

The coefficient of correlation of the degree of dispersion with the electro osmotic velocity was 0·798 which is significant at 1% level. Thus the electro-osmotic velocity of soils is a better index of their degree of dispersion, than the pH or the degree of sodium saturation, and the alkali condition as regards dispersion is more appropriately described by the electro-osmotic velocity than the other indices. The regression equation for this purpose is D. D. = 50·76 E. O. V. — 43·68.

Figures I, II and III show the scatter diagrams connecting the degree of dispersion with electro-osmotic velocity, degree of sodium saturation and pH respectively. Fig. II shows that point numbers indicating the serial numbers of the soil samples as given in table II, indicate that Nos. 1, 4, 5, 8 and 9 to a lesser ex-

Fig No. I

- Relation between degree of dispersion and electrosmotic velocity of soils.
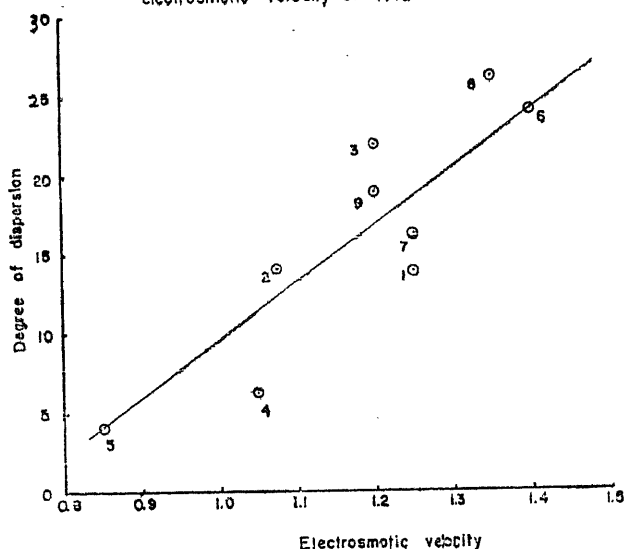
Electrosmotic velocity

Fig No. II

Relation between degree of dispersion and degree of sodium saturation of soils.

Degree of sodium saturation
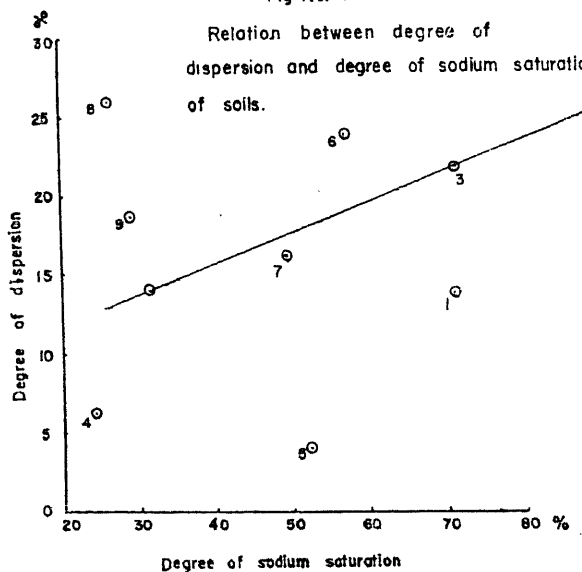
tent deviate from the general trend, shown by the other points. Table No. II shows that these are the samples having high percentage of organic carbon above 1%.

Fig No III

Relation between degree of dispersion and pH of soils
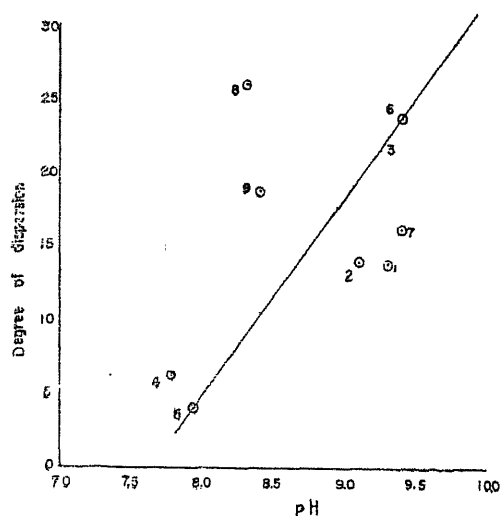
Of these, samples with high values of degree of dispersion are Nos. 8 and 9, and contain montmorillonite, while those deviating with lower values of degree of dispersion (1, 4 and 5) are those containing Illite or Kaolinite. Thus the lack of a significant correlation between the degree of sodium saturation and degree of dispersion seems to be due to higher amount of organic matter which seems to cause higher values of degree of dispersion in montmorillonite soils and low values in Illitie or Kaolinitic soils as compared to the normal mineral soils. Similarly in the degree of dispersion X pH scatter diagram those that are deviating with considerably higher values of degree of dispersion, are again Nos. 8 & 9 containing montmorillonite while those with considerably lower values (No. 1 & also 7 to less extent) are containing illite.

Figure IV shows the relationship between the degree of sodium saturation of the different soils and the cation exchange capacity which seems to show an inverse relationship between the two. This can be qualitatively explained on the basis of valency effect in the application of Donnan membrane equilibrium in clay suspensions as shown by Mattson (1948). According to this, the clay particles, having a high cation exchange capacity and hence high concentration of exchangeable ions on their surface, held calcium relative to sodium more tightly than clay particles having a low cation exchange capacity. There is an approximately linear inverse relationship between the cation exchange capacity and the degree of sodium saturation with a deviation from the linear relationship increasing on the side of high cation exchange capacity. Since this inverse relationship has been found for soils equilibrated with solutions of the same

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SAR, the degree of sodium saturation of soils can be taken to depend on the SAR of equilibrium soil solution and the cation exchange capacity of the soil and is not directly related to the degree of dispersion of soils.

Fig No.IV
Relation between cation exchange capacity and
degree of sodium saturation of soils equilibrated with
1:1 Ca : Na solution

— Linear relation in low range of C.E.C
----- Approximate inverse relationship
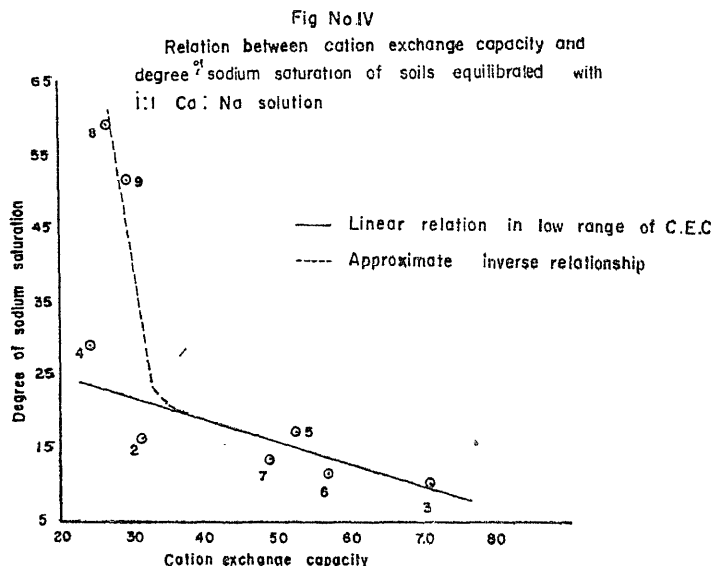
SUMMARY

    It has been found from an electro-chemical study of nine soils of different types, and the correlation between the degree of dispersion, which is important in assessing the poor physical condition of alkali soils, and the degree of sodium saturation, the pH, and the electro-osmotic velocity, that the electro-osmotic velocity is a better measure of the alkali conditions in the soil, than either the pH or the degree of sodium saturation. The poor coefficient of correlation between the degree of dispersion and degree of sodium saturation seemed to be due to the presence of high amount of organic matter which appears to cause greater dispersion in montmorillonitic soils and less dispersion in kaolinitic and illitic soils. The low correlation coefficient between pH and degree of dispersion seems similarily to be due to a greater dispersal than normal in montmorilliontic and less dispersion in illitic soils of the same pH.

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PHYSICO-CHEMICAL PROPERTIES OF MILK : PART II
EFFECT OF TEMPERATURE ON THE COAGULATION OF MILK WITH DIFFERENT ELECTROLYTES.

By

SUDHISH CHANDRA *and* A. C. CHATTERJI*

Chemistry Department, Lucknow University, Lucknow

ABSTRACT

Coagulation of milk was studied with six electrolytes at 25°, 30°, 35°, 40° and 45°C. It was found that the coagulation concentrations decreased on increasing the temperature and keeping the time of coagulation constant. Effect of dilution of milk on the coagulation concentrations for different electrolytes was also studied. It was observed that all the electrolytes studied excepting $(NH_4)_2SO_4$ obey the normal dilution law at all the five temperatures whereas $(NH_4)_2SO_4$ obeys the abnormal dilution law.

INTRODUCTION

A survey of the literature reveals that the coagulation of milk by heating has been studied by several workers (1) but no attention has been paid to study systematically the effect of temperature on the coagulation of milk by electrolytes. Such a study has been made in this paper.

EXPERIMENTAL

The coagulation concentrations for the different electrolytes were determined at five temperatures viz. 25°, 30°, 35°, 40° and 45°C. by performing the experiments in a water thermostat. The method of studying the coagulating concentration was the same as described in a previous paper (2). The average composition of milk used in these studies was:

Fat contents	$5 \cdot 5\%$
Total solids	$14 \cdot 0\%$
Non-fatty solids	$8 \cdot 5\%$

Two sets of test-tubes with the milk and the electrolyte were placed in the thermostat and after they had attained the temperature of the bath, the test-tubes were quickly taken out and the contents mixed. The both set of the test-tubes containing the milk and the electrolyte were placed back in the thermostat. The concentration of the electrolyte that produced coagulation was determined by taking out all the test-tubes after the required time of coagulation.

Present Address : Vice-Chancellor, University of Gorakhpur, Gorakhpur.

RESULTS AND DISCUSSIONS

TABLE 1

Coagulation of milk with Ferric nitrate at different temperatures

Vol. of milk	5ml.	Time ½ hour
Total vol.	10 ml.	

Conc. of milk	Coag. conc. in m. M. /l. at				
	25°C.	30°C.	35°C.	40°C.	45°C.
Pure milk	7·6	6·6	5·9	5·4	5·0
100 parts pure milk + 25 parts water	6·7	5·7	4·9	4·4	4·1
100 parts pure milk + 50 parts water	6·0	5·0	4·3	3·8	3·5
100 parts pure milk + 75 parts water	5·6	4·6	3·8	3·4	3·1
100 parts pure milk + 100 parts water	5·4	4·3	3·5	3·1	2·8

TABLE II

Coagulation of milk with Aluminium nitrate at different temperatures

Vol. of milk	5 ml.	Time ½ hour
Total vol.	10 ml.	

Conc. of milk	Coag. conc. in m. M. /l. at				
	25°C.	30°C.	35°C.	40°C.	45°C.
Pure milk	7·4	6·4	5·7	5·2	4·8
100 parts pure milk + 25 parts water	5·9	5·1	4·6	4·2	3·9
100 parts pure milk + 50 parts water	5·0	4 3	3·8	3·5	3·3
100 parts pure milk + 75 parts water	4·4	3·8	3·4	3·1	2·9
100 parts pure milk + 100 parts water	4·0	3·5	3·1	2·8	2·6

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TABLE III

Coagulation of milk with Zinc sulphate at different temperatures

Vol. of milk	5 ml.	Time ½ hour
Total vol.	10 ml.	

Conc. of milk	Coag. conc. in m. M. /l. at				
	25°C.	30°C.	35°C	40°C.	45°C.
Pure milk	9·8	8·6	7·8	7·0	6·5
100 parts pure milk + 25 parts water	8·3	7·3	6·6	5·9	5·4
100 parts pure milk + 50 parts water	7·4	6·5	5·7	5·2	4·7
100 parts pure milk + 75 parts water	6·5	5·6	5·0	4·6	4·3
100 parts pure milk + 100 parts water	6·0	5·2	4·6	4·3	4·0

TABLE IV

Coagulation of milk with Copper nitrate at different temperatures

Vol. of milk	5 ml.	Time ½ hour
Total vol.	10 ml.	

Conc. of milk	Coag. conc. in m.M/l. at				
	25°C.	30°C.	35°C.	40°C.	45°C.
Pure milk	8·5	7·4	6·6	5·9	4·6
100 parts pure milk + 25 parts water	6·1	6·3	5·6	5·0	4·0
100 parts pure milk + 50 parts water	6·1	5·4	4·8	4·3	4·0
100 parts pure milk + 75 parts water	5·3	4·7	4·2	3·8	3·5
100 parts pure milk + 100 parts water	4·7	4·1	3·7	3·4	3·1

TABLE V

Coagulation of milk with Nitric acid at different temperatures

Vol. of milk	5 ml.	Time ½ hour
Total vol.	10 ml.	

Conc. of milk	Coag. conc. in m. M. /l. at				
	25°C.	30°C	35°C.	40°C.	45°C.
Pure milk	8·6	6·4	5·2	4·4	4·0
100 parts pure milk + 25 parts water	7·5	5·5	4·4	3·8	3·4
100 parts pure milk + 50 parts water	6·5	4·8	3·9	3·4	3·0
100 parts water milk + 75 parts water	5·9	4·2	3·4	3·0	2·7
100 parts pure milk + 100 parts water	5·5	3·8	3·0	2·7	2·5

TABLF VI

Coagulation of milk with Ammonium sulphate at different temperatures

Vol. of milk	5 ml.	Time ½ hour
Total vol.	10 ml.	

Conc. of milk	Coag. conc. in m. M/l. at				
	25°C.	30°C.	35°C.	40°C.	45°C.
Pure milk	1076·0	1016·4	977·2	960·2	951·8
100 parts pure milk + 25 parts water	1088·2	1027·0	996·8	980·4	970·0
100 parts pure milk + 50 parts water	1096·0	1039·2	1010·0	995·1	986·2
100 parts pure milk + 75 parts water	1104·6	1045·6	1016·2	1004·2	996·4
100 parts pure milk + 100 parts water	1110·0	1050 4	1020·4	1010·8	1004·6

It is clear from the results that the concentration of the electrolyte required to coagulate milk goes on decreasing as the temperature increased provided the time of coagulation is kept constant.

The decrease in coagulation concentration on increasing the temperature can also be shown on the basis of the empirical equation given by Bhattacharya and Kumar (3). According to their equation the concentration c of an electrolyte added to a sol for coagulating it and the coagulation time t are related as:

$$\frac{1}{(c-a)} = \frac{nt}{m} + \frac{1}{m} \qquad (I)$$

where a, m and n are constants. This equation has been verified by them in a number of cases (4) and also it has been derived theoretically by Ghosh and Gangopadhyaya (5). The equation can be rewritten as:

$$c = \frac{m}{nt+1} + a \qquad (II)$$

On increasing the temperature the values of the constants a, m and n decrease. This has been shown by Verma (6) experimentally for the coagulation of Al $(OH)_3$, Fe $(OH)_3$ and Cr $(OH)_3$ sols and was theoretically derived from Ghosh and Gangopadhyaya's equation.

Hence it can be concluded that on increasing the temperature the values of the constants a, m, and n decrease. On keeping the coagulation time t constant, therefore, on increasing the temperature the value of c the concentration of the electrolyte required for coagulation will depend upon the variations in a, m and n. Since their values decrease with increase in temperature, the value of c will also decrease. Which is in accord with the results obtained here.

It is of interest to note that the coagulation concentrations of Fe $(NO_3)_3$, Al $(NO_3)_3$, Zn SO_4, Cu $(NO_3)_2$ and HNO_3 at every temperature decreased when the milk was diluted but with $(NH_4)_2SO_4$ the concentration increased. This was due to the fact that the coagulation of milk studied with $(NH_4)_2SO_4$ was in the second zone of coagulation i. e. the milk which was being coagulated had changed its charge from negative to a positive value by adsorbing excess of $\overset{+}{NH_4}$ ions. It has already been shown in the previous paper (loc. cit.) that the coagulation of milk in the second zone follows the abnormal dilution law whereas in the first, the normal dilution law.

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STUDIES IN ALKYL ESTERS OF 1-HYDROXY PHOSPHONIC ACID
PART III ESTERS FROM METHYL STYRYL KETONES

By

A. K. MISRA, K. D. SHARMA *and* J. B. LAL

Deptt. of Chemical Engg. and Technology, H. B. Technological Institute, Kanpur

ABSTRACT

In the present investigation authors have attempted to synthesise some new O, O dialkyl-α. hydroxy phosphonates by condensing benzylidene acetone and 4-methyl benzylidene acetone with dimethyl, diethyl, dipropyl diisopropyl, dibutyl diisobutyl, diisoamyl hydrogen phosphites in the presence of a few drop of sodium methoxide catalyst. These compounds may be regarded as Analogues of "Dipterex".

According to Fukuto[1] compounds having one reactive bond connected to the phosphorous atom possess high anticholinesterase activity. Further more, Eaton and Davis[2] have investigated that the compound having ($-ch=ch-\overset{\text{O}}{\underset{\text{C}}{\|}}-$) grouping possess good insecticidal activity.

Attempts have now been made to combine these insecticidally active groups in order to obtain additional and possibly improved insecticides. For this purpose reaction of dialkyl hydrogen phosphites with aldehydes and ketones was further extended to methyl-styryl ketones. These compounds were prepared by the condensation of benzylidene acetone, and 4-methyl benzylidene acetone with dimethyl, diethyl, dipropyl diisopropyl, dibutyl, diisobutyl, di (3-methyl *n*-butyl) hydrogen phosphites to obtain dialkyl esters of α-hydroxy phosphonic acid.

These compounds may be regarded as analogues of "Dipterex[3]" which is a useful toxicant as baits with lower mammalian toxicity. The catalyst employed in these condensations was sodium methylate (saturated). Sodium alkoxides from corresponding alcohols were also tried but the results obtained were not encouraging, although sodium alkoxides from corresponding alcohols were required in larger quantities for these condensations.

The reaction started at room temperature simply by the addition of few drops of catalyst (exothermic reaction) and was completed at higher temperature. The purified compounds obtained by fractional distillation were coloured liquids.

EXPERIMENTAL

1. Methyl Styryl Ketones:

(a) Benzylidene acetone[4] (Benzal-acetone) prepared by claison schmidt reaction of benzaldehyde and acetone.

(b) *p*-Toluidene acetone[5] (*p*-methyl benzalacetone) prepared by claison Schmidt Reaction of tolualdehyde and acetone.

TABLE 1

Dialkyl -α-hydroxy phosphonates

Sl No.	Name	Formula	% yield	State & colour	B P °C/mm	Phosphorous%	
						Found	Cal.
1.	O, O dimethyl-α-hydroxy-α-methyl α-cinnamyl phosphonate	$C_{12}H_{17}O_4P$	41·0	light yellow liquid	172-75/19	11·9	12·1
2.	O, O diethyl-α-hydroxy-α-methyl α-cinnamyl phosphonate	$C_{14}H_{21}O_4P$	52·0	,,	181-84/19	10·8	10·9
3.	O, O dipropyl-α-hydroxy α-methyl α-cinnamyl phosphonate	$C_{16}H_{25}O_4P$	61·0	,,	194-97/19	9·9	9·9
4.	O, O diisopropyl α-hydroxy -α-methyl α-cinnamyl phosphonate	$C_{16}H_{25}O_4P$	54·2	,,	192-95/19	9·8	9·9
5.	O, O dibutyl -α-hydroxy α-methyl α-Cinnamyl phosphonate	$C_{18}H_{29}O_4P$	63·0	Yellow liquid	199-202/19	9·0	9·1
6.	O, O diisobutyl-α-hydroxy-α-methyl α-cinnamyl phosphonate	$C_{18}H_{29}O_4P$	58·8	,,	206-9/19	8·9	9·1
7.	O, O di (3 methyl n-butyl) α-hydroxy-α-methyl α-Cinnamyl phosphonate	$C_{20}H_{33}O_4P$	55·0	Deep yellow liquid	202-7/18	8·3	8·4

TABLE 2

Dialkyl-α-hydroxy phosphonates

Sl No.	Name	Formula	% yield	State & colour	B P °C/mm	Phosphorous%	
						Found	Cal.
1.	O, O dimethyl-α-hydroxy-α-methyl α (4-methyl cinnamyl) Phosphonate	$C_{18}H_{19}O_4P$	42·7	Yellow liquid	185-88/20	11·4	11·5
2.	O, O diethyl-α-hydroxy-α-methyl α (4-methyl cinnamyl) Phosphonate	$C_{15}H_{23}O_4P$	47·9	Light Yellow liquid	193-95/20	10·3	10·4
3.	O, O dipropyl-α-hydroxy-α-methyl α (4-methyl cinnamyl) Phosphonate	$C_{17}H_{27}O_4P$	55·5	Light ,,	199-203/19	9·5	9·5
4.	O, O diisopropyl-α-hydroxy-α-methyl α (4-methyl cinnamyl) Phosphonate	$C_{17}H_{27}O_4P$	54·6	,,	197-98/19	9·4	9·5
5.	O, O dibutyl α-hydroxy-α-methyl α (4-methyl cinnamyl) Phosphonate	$C_{19}H_{31}O_4P$	56·4	Yellow liquid	207/10/20	8·6	8·8
6.	O, O diisobutyl-α-hydroxy α-methyl α- (4-methyl cinnamyl) Phosphonate	$C_{19}H_{31}O_4P$	56·8	,,	204-7/19	8·8	8·8
7.	O, O di (3 methyl n-butyl) α-hydroxy α-methyl-α (4-methyl cinnamyl) Phosphonate	$C_{21}H_{35}O_4P$	51·7	Deep Yellow liquid	206-10/20	8·0	8·1

2. *O, O dialkyl -α-hydroxy phosphonates*:

Method: Equimolecular quantities (0·01 mole) of benzylidene acetone or *p*-methyl benzylidene acetone and dialkyl hydrogen phosphite were mixed together in a conical flask. Saturated solution of sodium methoxide was added drop by drop with vigorous shaking causing the evolution of heat. The mixture was further shaken till the evolution of heat ceased. It required about 18-20 drops of sodium methoxide. The mixture was kept over water bath maintained at 95°C (±5) for half an hour.

The reaction products were then kept over night at room temperature, Next day, the mixture was diluted with water, extracted with benzene and dried over anhydrous sodium sulphate. Benzene was removed and the residue was fractionated under reduced pressure.

The properties, percent yield and percentage of phosphorous determined are given in table 1 and 2.

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ROTATORY POWER OF BRUCINE DERIVATIVES OF SOME ISONITROSO KETONES

PART I—BRUCINE DERIVATIVES OF ISONITROSO ACETOPHENONE, α-CHLORO-α-ISONITROSO ACETOPHENONE AND α-BROMO-α-ISONITROSO ACETOPHENONE

By

O. N. PERTI, G. C. SINGHAL, AND B. C. PANT

Department of Chemistry, Th. D. S. B. Government College, Naini Tal

ABSTRACT

Brucine derivatives of isonitroso acetophnenone, α-chloro α-isonitroso acetophenone and α-bromo-α-isonitroso acetophenone have been prepared and characterised. Their rotatory dispersion in chloroform and pyridine was found to be simple and could be expressed by one term of Drude equation. The effect of various groups on optical rotatory power in these derivatives is discussed.

INTRODUCTION

In an earlier communication[1] it was pointed out that the nitroso ketones exhibit a similar type of pentad tautomeric system as shown by 2—formyl ketones except that the trivalent = CH — of 2-formyl ketones is replaced by the trivalent = N -in nitroso ketones. In these compounds the electrons of the nitrogen atom are more nearly similar to those of the oxygen atom than those of carbon. This implies that in a system where there is competition between oxygen and nitrogen for the four electrone (*e.g.* in case of the nitroso form) the system would tend to go in the direction in which nitrogen will not compete with oxygen but will compete with carbon (*i.e.* the isonitroso form).

$$R - C(OH) = C. R.' - NO \rightleftharpoons R - CO - CHR' - NO \rightleftharpoons R - CO - CR' = NOH$$
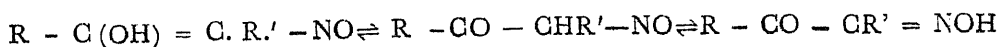
The result of this is that the isonitroso ketones exhibit a definitely acidic character and readily form salt like compounds with a base like brucine. In these paper the authors have described the brucine derivatives of isonitroso acetophenone, α-chloro-α-isonitroso acetophenone and α-bromo-α-isonitroso acetophenone and have studied their rotatory power.

EXPERIMENTAL

The isonitroso ketones required were prepared by the methods described earlier[2]. The brucine derivatives were obtained by mixing equimolecular

proportion of brucine and the isonitrose ketone in ethanol or ethanol-chloroform mixture. The solutions thus obtained were concentrated and allowed to stand when crystals of the salt separated out. They were purified by recrytallisation either from ethanol or ethanol-chloroform mixture. Their characteristics are given in Table 1.

TABLE 1

Characteristics of brucine derivatives of isonitroso ketones

Formula corresponding with analysis B = Brucine	Colour	M. P. (Uncorrected)	Analysis (Calculated values in brackets)		
			% C	% H	% N
1. C_6H_5 Co. CH=N. OH. B. $6\frac{1}{3}$ H_2 O Brucine-isonitroso-acetophenone	Light Brown	267°d.	56·06 (56·02)	6·29 (6·94)	6·72 (6·32)
2. C_6H_5. Co. C (Cl) = N. OH. B. $6H_2$ O Brucine-α-chloro-α-isonitroso acetophenone	Light yellow	269°d	55·07 (54·26)	6·67 6·41	5·70 (6·12)
3. C_6H_5-CO. C (Br) = N. OH. B. $2H_2O$ Brucine-α bromo-α-isonitroso aceto-phenone.	White	258°d	57·09 (56·53)	5·85 (5·47)	6·20 (6·38)

These compounds have practically similar solubilities. They are fairly soluble in pyridine and chloroform and practically insoluble in water, methanol, ethyl acetate, benzene, acetone, carbon tetrachloride, dekalin, dioxan, ether and petroleum ether.

The rotatory power determinations were made in a 2 dcm. tube and the results are recorded in Table 2, 3.

The rotatory power given in Table 2, 3 was analysed by the method of Lowry.[3] The compounds exhibited simple dispersion and the rotation in each case could be expressed by one term of Drude's equation. The calculated equations have been given in Table 2, 3.

TABLE 2

Rotatory power of brucine derivatives of isonitroso ketones in chloroform

Brucine derivative of :	isonitroso acetophenone	α-Chloro-α-isonitroso acetophenone	α-bromo-α-isonitroso acetophenone
Conc. in g/100ml	1·0128	1·2032	1·0484
Temperature°C	21·5	20	19
Calculated dispersion equation $(\alpha)_\lambda =$	$-\dfrac{1\cdot394}{-0\cdot2238}$	$-\dfrac{1\cdot805}{\lambda^2 - 0\cdot1427}$	$-\dfrac{3\cdot114}{\lambda^2 - 0\cdot1306}$
Wave Length (λ)	Obs. $(\alpha)_\lambda$	Obs. $(\alpha)_\lambda$	Obs. $(\alpha)_\lambda$
Hg 4358	—	− 38·23°	− 52·46°
Li 4603	—	26·18	38·15
Cd 4678	—	24·10	35·29
Cd 4800	—	20·77	·30·99
Cd 5086	— 39·98°	15·79	24·32
Hg 5461	18·75	11·63	18·59
Hg 5780	12·83	9·55	15 26
Na 5893	11·35	8·72	14·30
Li 6104	9·37	7·89	12·87
Ne 6402	7·89	7·06	11·44
Cd 6438	7·40	6·64	10·96
Li 6708	6·41	5·81	9·53

TABLE 3

Rotatory power of brucine derivatives of isonitroso ketones in pyridine

Brucine derivatives of	isonitroso aceto-phenone	α-chloro-α isoni-troso acetophe-none	α-brome-α-isonitroso acetophenone.
Conc. in g/100 ml.	1·0140	1·2092	1·0652
Temperature °C	20·5	20	20
Calculated dispersion equation $(\alpha)_\lambda =$	$-\dfrac{5·691}{\lambda^2 - 0·1319}$	$-\dfrac{5·437}{\lambda^2 - 0·1082}$	$-\dfrac{6·106}{\lambda^2 - 0·0884}$
Wave lenght (λ)	Obs. $(\alpha)_\lambda$	Obs. $(\alpha)_\lambda$	Obs. $(\alpha)_\lambda$
Hg 4358	—	– 66·15 °	—
Li 4603	—	52·51	—
Cd 4678	—	49·20	—
Cd 4800	—	44·24	—
Cd 5086	– 44·87°	36·38	– 35·67°
Hg 5461	34·51	28·94	29·12
Hg 5780	28·10	23·98	24·87
Na 5893	26·62	22·74	23·46
Li 6104	23·66	20·67	21·59
Ne 6402	20·71	18·19	19·24
Cd 6438	20·21	17·78	18·77
Li 6708	17·75	16·12	16·89

In table 4 the rotatory power of the compounds studied in this paper has been compared.

TABLE 4

Comparison of rotatory power

Structural formula B = brucine	(α) 5461		(M) 5461	
	CH.Cl$_3$	C$_5$H$_5$N	CH. Cl$_3$	C$_5$H$_5$N
1. B.HO.N. = C.OC.C$_6$H$_5$ $\mid$ H Brucine—isonitroso acetophenone	18·75	34·51	123·8	227·8
2. B.HO.N = C.OC.C$_6$H$_5$ $\mid$ Cl B-α-chloro-α-isonitroso acetophenone	11·63	28·94	79·84	198·6
3. B.OH.N = C.OC.C$_6$H$_5$ $\mid$ Br B-α-bromo-α-isonitroso acetophenone	18·59	29·12	122·3	191·6

From Table 4 it is seen that the effect of substitution of -Cl or -Br in place of hydrogen is to cause a lowering in the magnitude of rotatory power both in chloroform and in pyridine. At the same time substitution of -Cl in place of -H causes a greater lowering in the magnitude of rotatory power as compared to substitution of -Br in place of hydrogen if we compare specific rotatory power in either of the solvents used. However, if we compare the molecular rotatory power we find the effect quite marked in chloroform but not so in pyridine.

In an earlier study by one of us[4] in the case of derivatives of Reychler's acid it was noticed that the rotatory power shows a decrease by substituting -Cl in place of -H and, further, the decrease gets more marked as the number of -Cl groups in place of -H is increased. In a similar study[5] of the substitution of -Br in place of -H it was noticed that the decrease in the magnitude of rotatory power was quite noticeable in ethanol of chloroform but slightly anomalous results was

obtained in the case when the solvent used was pyridine which is a basic solvent having a high dielectric Constant (12·4). The striking difference in the rotatory power of Strychnine -p- nitrobenzoate in Chloroform and pyridine also points towards the role of solvent frequently masking the effect of the group on rotatory power[6].

The rotatory power of compunds studied in this paper shows that generally the substitution of electropositive -H by electronegative -Cl or -Br causes a lowering in the magnitude of rotatory power if the substitution takes place at a point not in the immediate vicinity of the optically active centre. Further, it is interesting to note that the effect is more marked in the case of -Cl substitution than in the case of -Br substitution. It is well known that -Cl is more eleetronegetive than -Br. The results obtained in this paper are also in conformity with those obtained by Singh and Barat earlier (7).

ACKNOWLEDGEMENT

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A STUDY ON THE FORMATION OF COMPLEX COMPOUNDS BETWEEN BIVALENT AND UNIVALENT SALTS VII

Systems : $Hg(CN)_2$ — KX - H_2O (where X = CNO or SeCN)

By

A. K. AGRAWAL

Chemistry Department, M. M. M. Engineering College, Gorakhpur

ABSTRACT

A preparative study of the systems : $Hg (CN)_2$ - KX - H_2O (X = CNO or SeCN) has been carried out and complexes of the type $KHg(CN_2)$ X have been isolated and found to remain unchanged on recrystallisation.

The mercury halide complexes of the type $(HgX_3)'$ and $(HgX_4)''$ are well known since long but the mixed pseudohalides and halide-pseudohalide complexes of mercury although studied earlier[1-4], have received considerable attention only for the last few years[5-7]. The author[8-13] has recently carried out a detailed study of the systems : HgX_2 - MCN — H_2O and $Hg(CN)_2$ - MX — H_2O(M = K, Na, NH_4 or Li and X = Cl, Br, CNS or I) and has isolated three different types of complexes $KHgX_2$ CN, $MHg_2(CN)_2X$ and $K_2Hg(CN)_4$. In this particular investigation a preparative study of the systems: $Hg(CN)_2$ - KX — H_2O (X = CNO or SeCN) has been carried out and complexes of the type $KHg(CN)_2X$ have been isolated.

EXPERIMENTAL

Materials.—B. D. H. chemicals (Laboratory Reagent) were used for the preparative work.

Analytical Methods.—Mercury was estimated as sulphide. In case of selenocyanate compounds, the precipitation was carried out in the ammoniacal medium so as to avoid the precipitation of elementary selenium. Selenium was estimated as the element gravimetrically by hydrolysing the compound with hydrochloric acid. Blanks were performed with known mixtures of potassium selenocyanate and mercuric cyanide and the results were found to be within two percent. Cyanate was estimated by holding cyanide in solution with formaldehyde and precipitating with silver nitrate without adding nitric acid due to the solubility of silver cyanate in it. Cyanide was estimated by conversion to bromine cyanide with bromine water, removing excess bromine with phenol, adding potassium iodide which liberated an equivalent amount of iodine which was titrated against thiosulphate using starch as indicator. In case of selenocyanate compounds, this method gave the total cyanide. Moreover, excess starch had to be added to eliminate interference in the detection of end-point due to selenium.

PREPARATIVE EXPERIMENTS

Products obtained from reaction mixtures having different molecular ratio of the reactants namely $Hg(CN)_2$ and KX in concentrated aqueous solutions have been analysed. In all cases, the compounds crystallised out in the form of white need-

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les soluble in water and corresponded to the general formula $KHg(CN)_2X$. However, mercuric cyanide crystallised out from the reaction mixture having the composition $Hg(CN)_2.KCNO$. In the table below are summarised the analyses of various products obtained from different molar ratio of the reactants.

Molar ratio of the reaction mixture.	Analysis of the product			Yield.
	Hg	CN	CNO/Se	
1. $Hg(CN)_2.KCNO$	79·0	20·3	nil	
Calc. for $Hg(CN)_2$	79·4	20·6		
2. $Hg(CN)_2.2 KCNO$	59·5	14·7	12·3	58·0 %
3. $Hg(CN)_2.4 KCNO$	59·8	15·0	12·2	65·0 %
$KHg(CN)_2.CNO$ requires:	60·1	15·6	12·6	
4. $Hg(CN)_2.K SeCN$	49·1	20·1	19·4	55·0 %
5. $Hg(CN)_2 2 K SeCN$	48·3	20·2	19·5	75·0 %
6. $Hg(CN)_2.4 K SeCN$	48·4	20·2	19·5	90·0%
$KHg(CN)_2.SeCN$ requires:	50·5	19·7	19·7	

The above compounds did not change in composition on recrystallisation showing that they are quite stable.

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THE

National Academy of Sciences, India

ANNUAL NUMBER

1964

THE THIRTY-FOURTH ANNUAL SESSION

By

ARUN K. DEY

Officer on Special Duty

The Thirty-fourth Annual Session of the Academy was held during February 13-15, 1965 at L. S. College, Muzaffarpur, at the invitation of the University of Bihar. The opening session, on the first day, was inaugurated by Shri M. Ananthasayanam Ayyangar, Governor of Bihar. In his inaugural address the chief guest emphasised the importance of science in modern societies and made a plea for a reinvestigation of the ancient sciences of India. He also emphasised that scientific research should be both fundamental and applied in nature.

The welcome address was read by Shri Satyendra Narayan Sinha, Minister for Education, Agriculture and L. S. G., Bihar, who was the Chairman of the reception committee. The President of the Academy, Professor P. Maheshwari was in the chair. Professor M. D. L. Srivastava, General Secretary, read the messages and the annual report.

The Uttar Pradesh Education Minister's Gold medals for 1964 were awarded to the following:

(1) Dr. R. D. Tiwari, M.Sc., D.Phil., F.N.A.Sc., Assistant Professor of Chemistry, University of Allahabad, Allahabad in "Chemistry and Technology".

(2) Dr. D. B. Saxena, M.Sc., D.Phil., F.A.Z., M.Z.S., F.I.H.S., P. G. Department of Zoology, J. & K. University, Srinagar in "Zoology, Medicine and Anthropology".

(3) Dr. D. P. Banerji, M.A., D.Sc., F.S.S., F.N.A.Sc., Professor and Head of the Mathematics Department, S. V. University, Tirupati in "Mathematics and Astronomy".

Votes of thanks were moved by Dr. P. L. Srivastava, Vice-Chancellor, University of Bihar, Professor M. D. L. Srivastava, General Secretary and Professor R. N. Tandon, Honorary Treasurer.

The session was attended by a large number of delegates including Dr. J. L. Kelley from U. S. A.

On the next two days, scientific sessions were held in two sections. The Physical Sciences section was presided over by Professor K. Banerjee, Director Indian Association for the Cultivation of Science, Calcutta. Forty-five research papers were presented in this section.

The section of Biological Sciences was presided over by Professor R. N. Tandon, Head of the Botany Department, University of Allahabad, Allahabad. One hundred papers were read and discussed in the section.

Three popular lectures were delivered by Professor P. Maheshwari, by Dr. J. L. Kelley and by Professor N. R. Dhar. Besides the Scientific programme, the local committee organised a number of social functions, including At Homes, lunches, dinners, entertainments and an excursion to Vaishali. The session was a grand success, and the academy is grateful to Dr. P. L. Srivastava and the local committee for the excellent organisation of the session.

PROGRAMME

SATURDAY, 13th February, 1965

2·30 p.m.   Annual Meeting (*L. S. College Quadrangle*).

1. Bande Mataram.

2. Appointment of two scrutineers by the President to count votes.

3. Reading of messages by the General Secretary.

4. Welcome Address by the Chairman, Receptions Committee, Shri S. N. Sinha, Education Minister, Bihar.

5. Annual Report by Prof. M. D. L. Srivastava, General Secretary.

6. Inaugural Address by Sri A. S. Ayyangar, Governor of Bihar.

7. Presidental Address by Prof. P. Maheshwari, President of the Academy.

8. Presentation of the Uttar Pradesh Education Minister's Gold Medals.

9. Introduction of Foreign Delegates by Padma Bhushan Dr. B. N. Prasad, Foreign Secretary.

10. Announcement of Office-bearers for 1965 by the General Secretary.

11. Thanks by Dr. P. L. Srivastava, Vice-Chancellor, Bihar University to the Chief Guest, Education Minister and the Academy.

12. Vote of thanks to the Chief Guest by Prof. M. D. L. Srivastava, General Secretary.

13. Vote of thanks to the University of Bihar by Prof. R. N. Tandon, Honorary Treasurer.

14. National Anthem.

Opening of the Book Exhibition by Sri A. S. Ayyangar, Governor of Bihar.

Group Photograph.

4.45 p.m.   'At Home' by the Chairman Reception Committee (*By invitation*).

6.00 p.m.   Popular lecture on "Plants and Human History" by Prof. P. Maheshwari.

7.00 p.m.   Entertainments.

8.15 p.m.   Dinner (*By invitation*).

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SUNDAY, 14th February, 1965

9.30 a.m.	Sectional President's Addresses :
	1. Physical Sciences (*Physics Lecture Theatre, L. S. College*)
	2. Biological Sciences (*Biology Lecture Theatre, L. S. College*)
10.30 a.m. to 12 noon	Sectional meetings : Reading of contributed papers :
	1. Section of Physical Sciences : Physics Lecture Theatre.
	2. Section of Biological Sciences : Biology Lecture Theatre.
1.00 p.m.	Lunch (*By invitation*).
2.00 p.m. to 4.30 p.m.	Sectional meetings (*Venues as above*).
4.45 p.m.	At Home (*By invitation*).
6.00 p.m.	Popular Lecture on "The Nature of Mathematics" by Dr. J. L Kelley.
7.00 p.m.	Entertainments.
8.15 p.m.	Dinner (*By invitation*).

MONDAY, 15th February, 1965

9 to 10 a.m.	Popular Lecture on "Energy Sources of the World" by Prof N. R. Dhar.
10 a.m. to 12 noon	Sectional meetings (*Venues as above*).
12.30 p.m.	Lunch (*By invitation*).
1 to 4-30 p.m.	Excursion to Vaishali.*

* Tea to be served at Vaishali.

MESSAGES

Dr. S. RADHAKRISHNAN, President of India

"The President sends his best wishes for the success of the 34th Annual Session of the National Academy of Sciences, India."

Shri LAL BAHADUR SHASTRI, Prime Minister of India

"The Prime Minister sends his good wishes for the success of the Thirty-fourth Annual Session of the National Academy .of Sciences, India, which will be held at Muzaffarpur from 13th to 15th February, 1965."

Shri BISWANATH DAS, Governor, Uttar Pradesh

"I am glad to know that the Thirty Fourth Annual Session of the National Academy of Sciences, India, is going to be held in February, 1965. The Academy, the oldest Scientific Academy of our country, has been doing splendid work during all these years for the development of science and scientific research. In the present age when Science holds the key to success and prosperity, the country owes a debt of gratitude to the National Academy of Sciences for scientific progress. There is yet much to be achieved, and I hope the Scientists assembled on the occasion of the session would do their best to accelerate this progress of scientific advancement not for destructive purposes but for the good of humanity.

I send my best wishes for the success of the session."

Shri H. V. PATASKAR, Governor, Madhya Pradesh

"I am glad to learn that the National Academy of Sciences, India, will be holding its thirty-fourth Annual Session from 13th to 15th February, 1965, at Muzaffarpur at the invitation of the University of Bihar.

I wish the Annual Session all success."

Shri M. C. CHAGLA, Education Minister, Government of India

"I am very glad to hear that the National Academy of Sciences of India is holding its 34th Annual Session in February, 1965, at Muzaffarpur.

Scientific academies in India have a very important role to play. It is heart ening to learn that this Academy has kept alive the interest in science and has been making useful contribution for its development. As is well-known, scientists cannot remain isolated and work in ivory towers. Science now demands a greater team work and systematically planned coordination for research. I am sure that the National Academy of Sciences of India would continue to play a significant role with its emphasis on intellectual advancement coupled with scientific integrity. I send my very good wishes for the success of the current session."

Shri KAILASH PRAKASH, Education Minister, Uttar Pradesh

"I am glad to know that the National Academy of Sciences, India, is going to hold its thirty-fourth Annual Session on February 13, 14 and 15, 1965, at Muzaffarpur. I hope the subjects that will be discussed at the Session will go a long way in the furtherence of scientific development in India. I wish the Session every success."

Dr. M. S. THACKER, Member, Planning Commission, New Delhi

"I know the good work the National Academy of Sciences, India, is doing. I send you my good wishes on the occasion of your Annual Session and wish the Academy success in its further work."

Dr. S. HUSAIN ZAHEER, Director General, Council of Scientific and Industrial Research, New Delhi

"I am happy to send my greetings to the 34th Annual Session of the National Academy of Sciences of India.

The role of Academies and Science Societies is considerable in the Promotion of Scientific atmosphere and scientific outlook. In addition to their role, with the growth and increase in science, the Societies and Academies have to play an increasing role in channelling science and scientific efforts into the proper direction.

The National Academy of Sciences has been fulfilling over the last 34 years a useful role in this direction and I wish this deliberation every success."

WELCOME ADDRESS

By

SRI SATYENDRA NARAYAN SINHA

Minister, Education, Agriculture and L. S. G., Bihar and
.Chairman, Reception Committee

SHRI RAJYAPALJI, MR. PRESIDENT, LADIES AND GENTLEMEN,

I consider it a proud privilege to have been given the opportunity to welcome you, the members of the National Academy of Sciences, India, to this place. Indeed, I thank you for having agreed to hold your conference at Muzaffarpur and I assure you, we feel honoured by the presence of distinguished delegates and visitors who have come here. But as I rise to bid you welcome, I am reminded of the gloom cast on the whole nation by the passing away or our beloved leader, and Prime Minister, late Pandit Jawaharlal Nehru. He was a man of letters and of science. On many such occasions, he had inspired you to give your best for the development and progress of our motherland. His greatest passion was to emancipate millions of his unfortunate men, women and children from the crippling bondage of poverty and illiteracy. He advocated increasing use of science and technology for a quicker development of our country. Alas, he could not see his dream realised and left us while the task was unfinished and the goal—the goal of socialism—distant. In my humble opinion, you learned men of science can pay no better tribute to his memory than by taking a pledge to use your talents for expanding the domain of science and for devising new techniques and instruments for speeding up the developmental activities in order to achieve the goal rapidly.

There is yet another situation which has created a sense of urgency. The Chinese explosion of nuclear device has thrown a new challenge and caused tension and anxiety not only in this country but in the entire South East Asian region and even in the whole world. Science, along with the methodology of scientific research, seeking to discover and establish truth in the structure and working of nature, is neutral and amoral with regard to the ends. But when the stage is reached of applying the discoveries of laws and principles of science to practical ends by means of technology, the scientists and the technologists come face to face with moral responsibilities whether the tools for controlling nature, created by them, are going to benefit, harm or even annihilate humanity. Clearly, therefore, the scientists as the creators of the forces and appliances which can shape a new world of happier humanity or can destory it, must assert the right to have a determining voice in the use of science and technology according to an ethical code. The voices of eminent scientists, philosophers and leaders of public opinon have already been raised in different parts of the world on this line. It would befit the culture and tradition of India, the land of Buddha, Mahabir and

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Mahatma Gandhi if the scientists assembled here take the lead in building up a universal ethical code for scientists.

These are the thoughts which are occupying my mind as I speak to you as your host. You have done a great honour to Muzaffarpur, the seat of the Bihar University, one of the newer ones in this State, by holding this session of your Academy here. But although this University is new, the place has the hoary and glorious traditions of long past. It was in this area, with its capital at Vaisali, a few miles from this place, that the direct democracy of the Lichhavis blossomed about twentyfive centuries ago and showed a vitality in surviving under and co-existing with the Imperial System of Pataliputra for centuries. This achievement of the region should inspire us to attain the goal of democratic socialism which is before us with this difference that modern socialism has to be built upon the productivity and plenty created by scientists and technologists.

The role of the sciences and the scientists has expanded enormously during recent years all over the world, and specially in India since our Independence. The innovations in the technological society of today begin in the scientific laboratories and on the desks of Mathematicians, but they do not produce ready-to-use prescriptions. Fundamental research has to make discoveries of scientific truths with the aid of mathematics and material tools and instruments. Most often the latter have got to be devised by the scientists themselves with the help of engineers. These have got to be passed on to the applied scientists and then to the developmental organisations. But the responsibilities of the scientists do not end here with even successful fundamental research. Those who teach the sciences in the Universities have to produce research workers on the one hand and teachers of sciences on the other so as to keep the stream of would-be scientists and engineers flowing from the schools to the Universities. Another stream of science graduates flows from the Universities to the Industries. So the scientists have to consider how far the syllabus in the Universities need such modifications as to guarantee high quality of all these streams flowing from the Universities to the research laboratories, to the schools and to the industries. It is for consideration as to how a more applied bias and practical training in handling instruments can be given in the Universities. It is also known that the laboratory appliances and Instruments in our Universities are very much out-of-date and whether the scientists should not take the lead in creating a new class of instrument engineers. Then, again, while the Universities may not impart the training needed in the industries to the fullest extent, the practical orientation has to be achieved in the University classes.

Another outsanding feature of the sciences of today, imposed by the technological age, is close interpenetration of all the sciences. The University scientist of today may not afford to be merely a specialist in any particular science of any specific branch of it. It is a day of problem research and solution in which the necessary team work is only possible if the research directors and guides are able to see what are the factors from the other sciences which have a bearing on a problem. Indeed, the modern scientist has got to combine breadth of knowledge, vision and imagination with depth in the field of his specialisation. The research section of the U. S. A. Defence administration alone employed 35,000 scientists and engineers during the last war apart from those in the Universities and private industrial research organisations. Research on such gigantic scales require a correspondingly large number of broad-visioned specialists as directors, guides and co-ordinators.

And finally, Universities and other scientific bodies as well as individual scientist have got to be in touch with other organisations like the Council for Scientific and Industrial Research in India, the National Research and Development Corporation, the Defence Department and so on, on the one hand, and with the trends of science and technology all over the world on the other. From the latter point of view it is a matter of great satisfaction that the Indian Government, Indian Scientific organisations and Indian scientists have been successfully cooperating in so many international scientific ventures in India and in the Indian Ocean.

I welcome all of you once more here and wish and hope that the deliberations of the meeting would be of great value to all, in particular to science teachers and students of this University, who are bound to be inspired to a more devoted and dedicated study of science and research. I crave your indulgence for the inconveniences you might have to put up with during your stay here.

INAUGURAL ADDRESS

By

SRI M. ANANTHASAYANAM AYYANGAR

Governor of Bihar

MR. PRESIDENT, MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, DELEGATES AND LADIES AND GENTLEMEN,

I am extremely happy that this Annual Conference of the National Academy of Sciences has been arranged to take place in the State of Bihar and I thank the organisers for having given me an opportunity to inaugnrate this session. I find from the previous proceedings that eminent men and scientists have discharged this task, like Pandit Jawaharlal Nehru and others. Panditji was a great lover of sciences. During the span of his premiership he established as many as 14 National Laboratories in this country. Let us on this occasion pay our humble tribute to his memory and may the succeeding generations be imbued with the same spirit and progressive ideals so as to make this country eminent in techno-logy and science.

On this occasion, let me also pay my tribute to those great scientists who are living and those that have passed away, like Sir C. V. Raman, Shri C. H. Bhabha, Sir J. C. Bose and Dr. K. S. Krishnan. Our country has produced persons like Ramanujam, the mathematical prodigy who won international fame and reputation. In recent days, Dr. Narlekar has won fame by his far-reaching research, particularly on the structure on the mass.

All of us are aware that this is an age of science and modern civilisation is entirely based on the researches of science and is built upon those researches. Wonders which were termed as miracles and said to have been performed by individuals are being worked through instruments. To-day we can now see scenes that occur miles away, you can hear the voice over thousands of miles away, we can fly at top speed in the sky and go round the earth several times in a day or dive deep into the sea ; we can hit distant targets by guided missiles and every limb of the body can almost be substituted by artificial limbs or by plastic surgery. Many diseases which were held to be incurable have been brought under control, if not sought to be wiped off the surface of the globe. With each new discovery, a new vista of knowledge throws itself open before the human mind. It is constantly expanding and seems to have unlimited scope for its activity and enterprise. Synthetic substitutes for food also have been discovered. In almost every field, western scientists have tried to break through the erstwhile impregn-able fortress of nature. They have conquered nature in every field and are still pursuing their inquiry, not content with the knowledge that they have acquired. Their thirst for knowledge has become a passion and is insatiable. That is what we can copy from the West to-day.

Some of these miracles were sought to be performed by our *yogis*, but the capacity of the mind to perform these wonders without external aids from machines is yet to be discovered by the West. Our scientists may pursue the scientific and technological researches made in the West and also initiate resear-ches into the fields of mind's activity and man's spiritual powers. Opportunities are great. The spirit of enquiry ought not to be killed, but must be allowed to

d evelop. No discovery seems to be final and no theory ean be taken for granted now. The erstwhile established theory is easily blown up by fresh discoveries. I want that spirit of enquiry and research to grow in every citizen in our country. There ought to l e no placc for blind tradition.

It is true that our ancients were also science-minded. Sir Bertrand Russel seemed to have humourously observed to our President, Dr. Radhakrishnan, that the contributian of India to scientific knowledge is cypher. Yes, the discovery of cypher to zero is our contribution to mathematical knowledge, as also the conception of infinity—

पूर्णमदः पूर्णमिदं पूर्णात् पूर्णमुदच्यते ।
पूर्णस्य पूर्णमादाय पूर्णमेवावशिष्यते ॥

Astronomical calculations started quite early in our country as well as research in the field of medicine. After having tried their hands in all sciences relating to the material world and the laws governing them, our people tried to find out the supreme law, or the law of laws, the fundamental cause of the Universe and the original source on which all other phenomena depended. In the Swetasvatara Upanishad we find a reference to a seminar held by aharishis in relation to the prime cause of the creator. They examined if 'kala' or time, 'swabhava' or nature, 'niyati' or predestination or 'yadriccya' or involuntary happening or 'bhutatiyonihi' or the combination of the five elements, their permutation and combination was the author of creation and ultimately arrived at the conclusion that there was a supreme Consciousness premeating the whole Universe, which is both its G. C. M. and L. C. M. and from which the creation emanated. The discoveries in science may lead us one day to the same conclusion. The splitting of the atom bomb into energy shows that all matter is derived from energy and as the energy in us is conscious, the next step may possibly lead to the conclusion that all energy is conscious energy. This is what is laid down in the Upanishads and what Sri Samkara has expounded in his Advaitik system of philosophy. This consciousness permeates the whole Universe and holds it together as laid down in the first verse of the Isopanished. The same Upanishad lays down that the whole Universe is in a state of flux and everything in this Universe moves.

After having attained the knowledge of inner self our ancients have in its practical application to life, preached contentment as the correct means to attain the highest happiness or bliss. While it may be true that for individual conduct contentment would be an ideal, the same principle ought not to be applied in regard to the society. Contentment acts as a deterrent to enquiry and research. Constant inquiry into and dissatisfaction with the existing conditions and a desire to improve them leads to further discoveries and a consequent betterment of the society as a whole. Therefore research should inform all our activities, otherwise with all our powers of speech and thought, we will continue to be guided and circumscribed by nature and cannot conquer it.

Even in the matter of discovery of the cause of creation and of oneself, we have not followed up the researches that our ancients made. They based their conclusions on scientific researches in other fields and ultimately arrived at that solution. Today, we do not know the steps and the stages by which they came to make the discovery that one supreme Consciousness is the cause of the Universe. The Yogasutra is intended to give one the knowledge of his inner self. Even there, there have been no practical experiments and demonstrations recently. There are

a few but they do not disclose in a scientific manner how they obtained that knowledge. Even in that field much scope lies for research.

We should no longer lag behind other countries in scientific knowledge and research. We should make up speedily the lag by intensive study of sciences both practical and theoretical and also in its application by technology. We have no doubt become free but we have not yet become free from hunger, want, diseases, illiteracy, unemployment and from other deficiencies. These are the enemies that we have to contend against.

Even war has become a scientific war today. That is a powerful nation which has discovered nuclear weapons and possesses them. At the root of that discovery is the scientist. It is, therefore, clear that from any point of view and for any purpose, whether for defence or internal economic and other progress, knowledge of science is absolutely necessary as also its application. We have therefore to become science and technology-minded as a nation.

To develop that attitude towards scientific knowledge, a beginning has to be made in the schools and continued right up to research institutes. There must be provision for instruction in the physical and natural sciences in every high school and in every college. For professorships in science colleges and in research institutes, the best students in science should be selected on a Statewise basis if not on an all-India basis. The highest emoluments ought to be paid to them and their conditions of service must be more attractive than the conditions of service relating to any other service in the country. They must further be given a position and rank in the society both in informal and formal gatherings. That is the only way in which we can draw the best talents and harness them for the good of the community. When some years ago I met Dr. K. S. Krishnan who was then the Director of the National Physical Laboratory, New Delhi, soon after his return from Russia, I asked him what attracted him most in Russia. He said that there existed in Russia a Brahmin class. I wondered what he meant. He said that the State has created a Brahmin class consisting of the eminent academicians, to whose care all scientific and technological research is entrusted. They are considered the topmost men in society in their respective fields, are paid the highest emoluments in the State and are held in high esteem. Unless the same place is given to the scientists and technologists in our society, our progress is not likely to be rapid or adequate. We are still drawing off the best of men to the administrative services and science institutes including research ones are not only not getting first-rate men but are getting depleted of competent men who run after the administrative services, where they can get better emoluments and exercise power and command better regard in the community. To convert the State into a real Welfare State, a change-over should take place early. The topmost men should be drawn with attractive emoluments and prestige to research institutes and to technological institutions. Care should be taken that no person, highly qualified with scientific knowledge is ever drawn off into the administrative or police services and allowed to waste his talents and the knowledge that the had acquired. This is the first and foremost change that has to come over in our recruitment policy.

Next to research institutes should come the professorships of colleges in the matter of emoluments and prestige. Those who are not wanted for these purposes alone should be taken for the administrative and other services. This will ensure adequate scientific personnel to man our research and technological institutes and colleges of science. Besides, the fourteen National Laboratories and others

must be worked with a missionary zeal. Agricultural production has to be doubled. The quality of the produce should also rise. Natural resources like coal, oil, gas and minerals must be explored and exploited. Many and different kinds of machines have to be built up and instruments designed. It is said that Adam Bede, a coffin-maker who is the hero of a novel of Jane Austin by that name saw the whole world in terms of coffins. When he saw a tree, he thought of the number of coffins he could make out of it. Whenever he saw a man, he thought of how big a coffin should be made for him. The analogy may not be a very happy one, but I mention it only to remind you that the scientists should try to utilise every material available for human needs by discovering the laws of its structure and its utility. We are in a bad economic condition and its reconstruction is not so much in the hands of the administrators as in the hands of scientists and technologists. Even the question of maintaining the freedom by the use of scientific discoveries is in their hands. There is no time to be lost. A very grave responsibility rests on your shoulders.

There was a team of scholars and scientists who came from America last year and held Summer classes by way of refresher courses for our teaching staff in the Universities and colleges attached to them. You may likewise organise some itinerant institutes for holding classes periodically for teaching the latest methods of scientific research and for teaching in schools, colleges and other institutions.

It has no doubt been said that discoveries of sciences through their application as in the case of nuclear weapons may harm humanity. It is true that knowledge can both be used and abused and that ought not to be any reason for not to develop the scientific research and knowledge by thoroughly probing into the laws of the universe. We have resolved in our country not to use the nuclear energy for destruction but only for peaceful purposes.

While much of the discoveries of science in all fields of human activity have been made in recent times by western scholars, our scholars also can contribute to the scientific knowledge by working on the western lines and pursuing their researches. They can also add to that knowledge by making researches into some of the things that our ancients had discovered. We have Sastras or treatises on many sciences in our land. There is the Rasayana Sastra, Vriksha Sastra, Jantu Sastra, Ganita Sastra, Nakshatra Sastra, Asva Sastra, Vastu Sastra, Silpa Sastra and others. Our ancients used both Astras and Sastras for warfare. While Sastra is said to be mechanical weapons of warfare, Astras are described as weapons for the use of which scientific skill or spiritual knowledge is necessary. What these are or mean will be useful and interesting subjects for research.

You may create a central library under the auspices of your Academy and maintain therein a collection of all our ancient treatises on these various branches of scientific knowledge. Comparative study of the discoveries by our ancients must also be introduced in the respective colleges. Knowledge no doubt is not limited to a clime, country or a group of men. While it is good, if not necessary, to obtain knowledge from any source, the knowledge that we can obtain from our ancient literatures on sciences ought not to be ignored. Indian scientists and technologists can play a special role in research. They can study our ancient books and give out the knowledge to the world. They have this opportunity which others may not have. Many things have been discovered in our country also and we have had an ancient and glorious civilisation. I would suggest that you address yourselves also to this aspect of study and try to make reserches, particularly in the matter of our drugs, their efficacy and usefulness. There ought

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'to be co-operative study of scientific literature and the knowledge which we derive from the west.

Along with the making of researches the spread of knowledge of the researches is equally important for the growth of that knowledge. I would also urge upon you to constitute a committee to go round the country from time to time and assess the work that is being done in the various research institutes and National Laboratories and suggest improvements thereof. We must catch up with the other scientifically and technologically advanced countries in the world and this progress is entirely in the hands of scientists. Please address yourself to the various problems that our country is facing which requires scientific knowledge and application and try to help both in the matter of defence of the country and in the economic reconstruction that has been undertaken by the Five-Year Plans. Researches must, therefore, be both fundamental and applied. I hope and trust that your discussions and deliberations will be carried on in a healthy and constructive spirit and that you will give a new lead to the country and its economic progress.

I once again thank you for the honour you have done me in asking me to inaugurate the Conference. I gladly do so and wish the Conference every success

SECRETARIES' REPORT

By

Prof. M. D. L. SRIVASTAVA, D.Sc., F.N.A.Sc.

We have pleasure in submitting the following report on the working of the Academy during the period 1st January to 31st December, 1964.

MEMBERS

The Academy had on its rolls 387 members in good standing, of whom 138 were Fellows.

The following new members have been elected and enrolled during the year and we take this opportunity of welcoming them :

1. Dr. P. S. Ramakrishnan, M.Sc., Ph.D., Department of Botany, Panjab University, Chandigarh.

2. Shri G. K. Goyal, M.Sc., Lecturer in Mathematics, University of Rajasthan, Jaipur.

3. Shri J. M. Gandhi, M.Sc., Reader in Physics, Maharani's College, Jaipur.

4. Shri P. N. Rathie, M.Sc., Lecturer in Mathematics, Faculty of Engineering, University of Jodhpur, Jodhpur.

5. Prof. J. N. Kapur, M.A., Ph.D., Head of the Mathematics Department, Indian Instititute of Technology, Kanpur.

6. Shri Z. U. Ahmad, M.Sc., Senior Research Assistant, Section of the Plant Pathologist to Government U. P., Kanpur.

7. Shri M. N. Hakoo Koul, M.Sc., Research Scholar in Botany, Banaras Hindu University, Varanasi-5.

8. Dr. B. L. Mathur, M.Sc., Ph.D., Asst. Plant Pathologist, Plant Pathology Section, A-30, Tilak Nagar, Jaipur.

9. Dr. R. K. Gupta, M.Sc., Ph.D., Research Officer, C/o French Institute, P. O. Box 33, Pondicherry.

10. Shri H. M. Srivastava, M.Sc., Lecturer in Mathematics, University of Jodhpur, Jodhpur.

11. Shri S. K. Sharma, M.Sc., Junior Scientific Officer, Room No. 31, National Physical Laboratory of India, New Delhi.

12. Shri Krishnaji, M.Sc., Offg. Reader in Physics, University of Allahabad, Allahabad.

13. Shri S. C. Rajvanshi, M.Sc., Lecturer in Mathematics, University of Jodhpur, Jodhpur.

14. Shri S. L. Gupta, M.Sc., Lecturer in Mathematics, University of Jodhpur, Jodhpur.

15. Dr. P. K. Bhatia, M.Sc., Ph.D., Lecturer in Mathematics, University of Jodhpur, Jodhpur.

16. Shri D. C. Gokhroo, M.Sc., Research Scholar in Mathematics, M. R. Engineering College, Jaipur.

17. Dr. L. N. Vyas, M.Sc., Ph.D., Head of the Botany Department, M. B. College, Udaipur.

18. Dr. D. C. Sarkar, Ph.D., Head of the Physics Department, Muslim University, Aligarh.

19. Shri T. J. Varkey, M.Sc., Head of the Chemistry Department, Karnataka Regional Engineering College, Surathkal.

20. Shri Udai Narain, M.Sc., Head of the Botany Department, Rajendra College, Chapra.

21. Shri S. K. Kulshreshtha, M.Sc., Research Scholar in Mathematics, University of Rajasthan, Jaipur.

22. Shri T. R. Sukhani, M.Sc., Lecturer in Zoology-Entomology, Government Agricultural College, Kanpur.

23. Shri R. N. Singh, M.Sc., Research Assistant, Botany Division, Indian Agricultural Research Institute, New Delhi—12.

24. Shri M. P. Dwivedi, M.Sc., Lecturer in Zoology, Government Science College, Jabalpur.

25. Dr. A. N. Goyal, M.Sc., Ph.D., Lecturer in Mathematics, Maharaja's College, Jaipur.

26. Shri D. Ramakrishna Rao, M.Sc., Lecturer in Mathematics, Department of Technical Education, Nehru Nagar, Secunderabad.

27. Shri G. U. Nair, M.Sc., Research Assistant, Botany Department, Christ Church College, Kanpur.

28. Shri P. C. Chatterji, M.Sc., Geologist, Central Arid Zone Research Institute, Jodhpur.

29. Dr. P. K. Bhattacharya, M.Sc., Ph.D., Lecturer in Chemistry, Vikram University, Ujjain.

30. Miss Vinod Agarwal, Research Scholar in Zoology, University of Lucknow, Lucknow.

31. Shri D. K. Mandal, M.Sc., Zoological Assistant, Insect Section, Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta— 12.

32. Shri R. S. Pathak, M.Sc., Research Scholar in Mathematics, Banaras Hindu University, Varanasi—5.

33. Shri S. P. Chhabra, M.Sc.. Assistant Professar of Mathematics, Government College, Shahdol.

34. Shri P. C. Sharma, M.Sc., Research Scholar in Botany, University of Lucknow, Lucknow.

35. Shri Krishna Lal, M.Sc., Lecturer in Engineering Mathematics, Engineering College, Banaras Hindu University, Varanasi—5.

36. Shri D. Rameshwar Rao, M.A., Research Scholar, 11-1-243, Sitafalmandi, Secunderabad.

37. Shri R. S. Gupta, M.Sc., Offg. Reader in Mathematics, University of Allahabad, Allahabad.

38. Dr. R. C. Khare, M.A., D.Phil., Lecturer in Mathematics, University of Allahabad, Allahabad.

39. Dr. A. K. Agrawal, M.Sc., Ph.D., Lecturer in Chemistry, M. M. M. Engineering College, Gorakhpur.

40. Shri R. Dasvarma, M.Sc., Reader in Mathematics, University of Bihar, Muzaffarpur.

41. Shri C. S. Pandit, M.Sc., Lecturer in Chemistry, Holkar Science College, Indore.

42. Shri V. K. Verma, B.Sc. (Hons.), M.Sc., Lecturer in Geology, Faculty of Engineering, University of Jodhpur, Jodhpur.

43. Shri R. C. Verma, M.Sc., Reader in Mathematics, Government Engineering College, Jabalpur.

44. Shri Sudhanshu Harit, M.Sc., Lecturer in Mathematics, G. R. C. College, Fatehpur.

45. Shri S. K. Potay, M.Sc., Senior Scientific Assistant, Defence Mettalurgical Research Laboratory, Phisalbanda, P. O. Yakutpura, Hyderabad.

46. Shri Digamber Rao, M.Sc., Research Scholar in Botany, Osmania University, Hyderabad.

47. Dr. V. Kaul, M.Sc., Ph.D., Head of the Post Graduate Department of Botany, J. & K. University, Srinagar.

48. Shri S. Md. Shafi, M.Sc., Lecturer in Zoology, Ranchi College, Ranchi.

49. Dr. S. R. Mukherjee, M.A., D.Phil., Lecturer in Engineering Mathematics, Engineering College, Banaras Hindu University, Varanasi—5

50. Dr. C. L. Mandahar, M.Sc., (Hons.), Ph.D., Lecturer in Botany, Kurukshetra University, Kurukshetra,

FELLOWS

We are happy to announce the election of the following new Fellows of the Academy during the year 1964 :

1. Prof. J. B. Lal, D.Sc., B.S.E., M.S.E., F.I.C., M.I. Chem. E., Head of the Department of Chemical Engineering and Industrial Chemist to the Government U. P., H. B. Technological Institute, Kanpur.

2. Dr. R. P. Patil, B.A., M.Sc., Ph.D., Botanist, Central Botanical Laboratory, 43, Lansdowne Road, Calcutta—20.

3. Dr. G. S. Sidhu, B.Sc. (Hons.), M.Sc., Ph.D., Director, Regional Research Laboratory, Hyderabad.

MEETINGS

During the year under review, ten meetings of the Council, ten meetings of the General Body, and two meetings of the Fellows were held. Besides transactions of business, papers were read and discussed at the ordinary meetings.

THIRTY-THIRD ANNUAL MEETING

The Thirty-third annual meeting of the Academy was held at the University of Allahabad on February 15 and 16, 1964. This meeting was held principally to transact official business and no sessions for the reading of papers were held. However, it was possible to organize two symposia : one on (1) The Chemistry of Natural Products and the other on (2) Land Fertility, Improvement and Alkali Soil Reclamation by Blue Green Algae, which met with great success. A large number of papers were presented at these symposia.

The annual meeting was atteneded by a large number of delegates from all over the country. Dr. Miss E. C. M. Segar, a Botanist from New Zealand, was also present.

The meeting was inaugurated by Dr. S. Bhagavantam, Scientific Adviser to the Minister for Defence, Government of India. In his address on 'Physics of the Earth' he said that the study of the earth had revealed that our planet is an infinitesimal part of the Universe both in respect of size and time. Man has been trying to know more and more about the earth. With their attempts towards this end they have developed a greater urge to conduct further researches.

Professor P. Maheshwari, President of the Academy, presided over the annual meeting. His presidential address was on "Science and Government." In his address he made some observations on the conditions under which science floursihes in India and discussed the handicaps that have to be faced by scientists in this country and made some valuable suggestions.

A popular lecture was delivered by Dr. S. Bhagavantam on "Symmetry : its Principles and Practice."

The Academy is thankful to the Vice-Chancellor, University of Allahabad, for allowing the use of the premises of the University for holding the annual meeting of the Academy. The cooperation of the members, the participants, and all the others who attended the session is greatly appreciated.

COUNCIL

The following constituted the Council of the Academy during 1964.

President

Prof. P. Maheshwari, D.Sc., F.N.I., F.B.S., F.A.Sc., F.N.A.Sc., Head of the Botany Department, University of Delhi, Delhi.—7

Vice-Presidents

Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Foreign Associate Member of French Academy of Agriculture and Corresponding Member of French Academy of Science, Director, Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.

Prof. S. Ghosh, D.Sc., F.N.I., F.N.A.Sc., Head of the Department of Chemistry, Dean, Faculty of Science and Rector, University of Jabalpur, Jabalpur.

Honorary Treasurer

Prof. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.N.I., F.A.Sc., F.N.A.Sc., Head of the Botany Department, University of Allahabad, Allahabad.

Foreign Secretary

Padma Bhushan Dr. B. N. Prasad, Ph.D., D.Sc., F.N.I., F.N.A.Sc., M.P., Retired Professor of Mathematics, University of Allahabad, Allahabad.

General Secretaries

Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc., Dean, Faculty of Science, University of Allahabad, Allahabad.

Dr. M. L. Dhar, M.Sc., Ph.D., F.R.I.C., F.N.I., F.N.A.Sc., Director, Central Drug Research Institute, Lucknow.

Members

Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., F.N.I., I.E.S. (Retd.), F.N.A.Sc., Ex-Vice-Chancellor, University of Allahabad, Allahabad.

Dr. S. Ranjan, D.Sc., F.N.I., F A.Sc., F.N.A.Sc., Ex-Vice-Chancellor, University of Allahabad, Allahabad.

Col. Dr. P. L. Srivastava, M.A., D.Phil., F.N.I., F.N.A.Sc., Vice-Chancellor, Bihar University, Muzaffarpur.

Prof. R. S. Mishra, M.Sc., Ph.D., D.Sc., F.N.I., ·F.N.A.Sc., Head of the Mathematics Department, University of Allahabad, Allahabad.

Prof. P. S. Gill, M.S., Ph.D., M.A.P.S., F.N.I., F.N.A.Sc., Director, Central Scientific Instruments Organization, Chandigarh.

Prof. A. K. Bhattacharya, D.Sc., F.R.I.C., F.N.A.Sc., Head of the Chemistry Department, University of Saugar, Sagar.

Prof. S. N. Ghosh, D.Sc., F.N.A.Sc., J. K. Institute of Applied Physics, University of Allahabad, Allahabad.

Prof. R. Misra, M.Sc., Ph.D., F.B.S., F.N.I., F.N.A.Sc., Head of the Botany Department, Banaras Hindu University, Varanasi.

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REPRESENTATIONS ON OTHER ORGANISATIONS

The Academy was represented by the following members on other organizations and learned bodies :

1. Padma Bhushan Dr. B. N. Prasad, Ph.D., D.Sc., F.N.I., F. N. A.Sc., M. P., Additional Member, Council of National Institute of Sciences of India, New Delhi.

2. Prof. N. R. Dhar, D.Sc., F. N. I., I. E. S. (Retd.), Member of the Indian National Commission for Cooperation with UNESCO.

3. Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc., A representative of the Academy on the Court of the Lucknow University.

FINANCES

The financial position of the Academy is given in the Financial Statement for 1963-64 ending on the 31st March, 1964.

The Academy is thankful to :

1. The Government of India,

2. The Government of Uttar Pradesh,

3. The University of Allahabad,

and 4. The National Institute of Sciences of India, New Delhi, for the assistance received from them.

The Academy still continues to work under great difficulties for shortage of funds. The office, the publication section and the library require to be streamlined to meet the expanding needs of the Academy and we require more office and administrative staff for efficient working.

PUBLICATIONS

We have been able to keep our publication more or less up-to-date. The main difficulties that are being faced have been with the printing presses and the procurement of quality paper for our Proceedings. During the year we have been able to publish 3 parts of Section A, 4 parts of Section B and the Annual Number of 1963.

LIBRARY

We have been able to regularise the exchange of periodicals to a large extent, which, however, still requires considerable improvement to bring the library to the standard expected of a good scientific library. It is very essential to enlarge our exchange list and also to equip ourselves with a number of periodicals not available in exchange, but we are handicapped for want of funds.

AWARD OF U. P. GOVERNMENT EDUCATION MINISTER'S GOLD MEDAL

We have great pleasure in announcing that the Uttar Pradesh Government Education Minister's Gold Medals for 1964 for the best research work have been awarded to the following :

1. Dr. R. D. Tiwari, M.Sc., D.Phil., F.N.A.Sc., Assistant Professor of Chemistry, University of Allahadad, Allahabad in "Chemistry and Technology".

2. Dr. D. B. Saxena, M.Sc., D.Phil., F.A.Z., M.Z.S., F.I.H.S., P. G. Department of Zoology, J. and K. University, Srinagar in "Zoology, Medicine and Anthropology".

3. Dr. D. P. Banerji, M.A., D.Sc., F.S.S., F.N.A.Sc., Professor and Head of the Mathematics Department, S. V. University, Tirupati in "Mathematics and Astronomy".

GENERAL OBSERVATIONS

This Academy, which was established in 1930, is the oldest Scientific Academy in this country. It has on its rolls representatives from every part of this country and from various disciplines of scientific activity. Many foreign scientists and some of our statesmen are associated with us as honorary fellows of the Academy. The Academy has always welcomed scientific workers to join the membership. We seek the cooperation of all those interested in science to join hands with us for the scientific advancement of the country.

ACKNOWLEDGEMENTS

Finally, we record our thanks for the ungrudging help and cooperation we have received from the referees of papers, the scruitinizers of voting papers, the judges for assessing the papers for the Award of U. P. Education Minister's Gold Medals, the members of the Academy, the printing presses and the office staff, during the period under review in this report.

FINANCIAL STATEMENT FOR THE YEAR 1963-64

RECEIPTS

		Rs.
1.	Opening Balance ...	2,425·77
2.	U. P. Govt. recurring grant for 1963-64 ...	6,000·00
3.	Government of India non-recurring grant for 1963-64 ...	10,000·00
4.	Allahabad University grant for 1963-64 ...	1,000·00
5.	Grant from the National Institute of Science of India, New Delhi ...	4,000·00
6.	Membership Subscription (Life)	1,738·00
7.	Membership Subscription ...	3,247 75
8.	Sale of Proceedings ...	7,875·26
9.	Cost of Reprints ..	434·58
10.	Bank Commission ...	13·93
11.	Transferred from Reserve fund ...	11,000·00
12.	Provident fund contribution by the staff ...	293·93
13.	Miscellaneous income ...	15·87
14.	Interest on fixed deposit (Reserve fund) ...	0·58
15.	Sale proceeds of waste paper ...	72·00
16.	Fines ...	4·00
17.	Difference of conversion of dollars	1·48
18.	Loan realised ...	60·00

48,183·15

PAYMENTS

Recurring   Rs.

		Rs.
1.	Establishment ...	6,106·09
2.	Dearness allowance ...	2,061·05
3.	Provident fund ...	587·86
4.	Postage ..	2,982·14
5.	Printing and Stationery ...	1,090·07
6.	Annual Session expenditure ...	466·62
7.	Transfer to Reserve fund ...	12,824·36

   (a) Refund of amount taken from Reserve fund   Rs. 11,000·C0
   (b) Life membership fee received during 1963-64 Rs. 1,738·00
   (c) Transfer the amount of the dollars 27,00 received during 1962-63   Rs. 125·78
   (d) Interest on Fixed deposit   Re. 0·58

             12,864·36

Less the amount refunded to Dr. Choudhry   40·00

             12,824·36

8.   Cost of Publication of Journals ... 18,491·47
   (a) Mission Press   Rs. 7,493·68
   (b) Capital Printing Works   Rs. 7,037·35
   (c) Cost of paper   Rs. 3,960·44

             44,609·66

Non-Recurring
9.   *Expenditures*   ... 2,198·81
   (a) Bank charges devalution of dollars   95·21
   (b) Loan of Sri Nanku Ram   50·00
   (c) Repairs of buildings   187·25
   (d) Binding charges   58·00
   (e) Subscription Account   100·00
   (f) Advertisement   160·00
   (g) Gold Medals   435·00
   (h) Refund of excess amount of the Proceedings   30'00
   (i) Contingent Expenditure 1,083·35

    Grand Total   46,808·47
10. *Closing Balances*   ... 1,374·68
    Cash in hand   ... 14·35
    Cash at Bank   ... 1,360·33

          Total   **48,183·15**

Examined with the books and vouchers, certified correct to the best of our knowledge, information and belief.

Dated April 22, 1964.

(Sd.) G. P. JAISWAL

for G. P. JAISWAL & Co.

Chartered Accountants

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PRESIDENTIAL ADDRESS

BIOLOGY AND HUMAN WELFARE

By

Professor P. MAHESHWARI D.Sc., F.N.I., F.B.S., F.A.Sc., F.N.A.Sc.

Head of the Botany Department, University of Delhi, Delhi

MEMBERS OF THE ACADEMY, LADIES AND GENTLEMEN !

I consider it a great honour and a privilege to stand before you once again and preside over the 34th annual meeting of the National Academy of Sciences. Last year I had the pleasure of speaking to the members of the Academy on the relation between Science and Government. Being a Biologist, it is only proper that this time I should talk to you on the role of biology in human welfare.

Much of our material progress in modern times is due to science. All our modern facilities of communication (trains, steamships, telephones, telegraphy, radio, television, automobiles, jet planes, and space ships) stem from discoveries in physical sciences. Thus, the "Puffing Billy" first hauled coal in 1813 and the first railways for passengers were opened in 1830. In 1838 the steamship "Sirius" crossed the Atlantic in 19 days, and the first telegraphic messages between the UK and the USA were exchanged in 1858. Recently we have been hearing of space flights and interplanetary flights and we are promised a landing on the moon in 10 or 20 years although a safe return is not guaranteed. Chemists have provided us with many synthetic substances like glass, bakelite, plastics, rubber, dyes, perfumes. In addition we have many other things like washing machines, pressure cookers, electric lighting and heating, electric fans, air-conditioners, printing presses, typewriters and so on, which even kings and monarchs did not possess in the past. All these developments have taken place within the last 150 years or less.

The above achievements in the physical sciences are indeed important and even spectacular but those in the biological sciences are no less so. Consider, for instance, some of the advances in medicine. In the 19th century only one baby in India survived out of four or five. Now three or four survive out of five, and in western countries infant mortality has been reduced to only 1%. Small-pox, plague, typhoid, malaria and cholera were common in the living memory of the older ones amongst us. Today we have controlled almost all of them except diseases like cold and influenza which are caused by viruses. Our understanding of these infectious diseases began with the work of Pasteur who first showed the role of microorganisms in fermentation and in the spread of disease. On the one hand, this was followed by things like vaccination, preventive inoculation and injections of antitoxin. On the other hand, there came some particular advances in surgery. Up to the middle of the 19th century about half the amputations resulted in death and percentage was much higher in cases of abdominal surgery. This was not primarily due to the injury sustained in the surgical operation but to the after-effects caused by infection of the wound by bacteria. When Lister, a British surgeon, learnt of Pasteur's work on microorganisms, he introduced new methods of antisepsis and asepsis. About the same time anaesthetics were also introduced with the result that operations became virtually painless and the number of deaths in surgical wards quickly declined. With the discovery of the sulpha drugs and antibiotics like penicillin the situation has improved still further,

THE POPULATION EXPLOSION

The general decline in death-rate and the great decrease in infant mortality has, however, raised other problems. The population is steadily increasing and tends to double itself in only about 40 years. While formerly we were threatened by disease, today we are threatened with something worse, *i.e.* starvation. It is said that in the days of Megasthenes India was a land of milk and honey, but at present the position is quite different. We are now importing foodstuffs from other countries and in spite of frequent promises toward self-sufficiency our position continues to deteriorate year by year. What are the causes of this misfortune ? Well, even a hundred years ago the population of India was only 100–150 million. When I was a school boy fifty years ago, it was 300 million and now in my children's days the population of the Indo-Pakistan subcontinent is nearly 600 million. What it may be toward the end of the century is anybody's guess, but demographers do not hesitate to place it near about 1000 million. One expert has said that if all the human beings of the world died as the result of a sudden catastrophe, and only one Indian, Chinese or Indonesian couple survived, the world would be fully rehabilitated in 600 years. This estimate assumes that each couple would have four or five children during their lifetime which nearly approaches the average number in south-east Asia.

This tremendous increase in population, caused by a steady birth rate and a declining death rate, has given rise to serious problems not only of underfeeding but also of improper feeding. Mr Raymond Ewell of the New York University has recently predicted that unless proper steps are taken famine might reach serious proportions in India, Pakistan and China in the early 1970s. He warns that "this would be a famine on a scale never before experienced in the world's history" and that "a stable government is unlikely to be maintained in countries where a high percentage of the population is literally starving." Hunger fetches the wolf out of the woods, it demoralizes people and promotes thieving and robbery. A Sanskrit poet has said :

बुभुक्षितः किं न करोति पापं,
क्षीणा नरा निष्करुणा भवन्ति ।

METHODS OF INCREASING OUR FOOD SUPPLY

Before discussing this point further it is important to realise that there is only one ultimate source of food for men and animals, whether they are vegetarians or non-vegetarians. This comes solely from plants. They alone have a green pigment called chlorophyll with the help of which they can combine, in the presence of light, two simple things—carbon dioxide and water—and produce sugars, starches and various other substances on which our life and happiness depend. Animals do not possess this property and in spite of his ingenuity man has not succeeded in unravelling all the mysteries of this master chemical reaction. Give the most brilliant chemist of the world all the furnaces, retorts, catalysts and complicated glassware, and he can produce only soda water from carbon dioxide and water. While one line of work no doubt is to try to understand more about the photosynthetic reaction, and duplicate it in the laboratory, another and more fruitful line at least for the immediate future, is to study the plant itself and make it do a better job than it is doing already.

As to the means of increasing our food supplies, we could then try one or several of the following methods: (*a*) increase the area of land under cultivation ; (*b*) increase the area under food crops while reducing that under some others ; (*c*) improve the yield per acre of existing land ; (*d*) produce food from the sea, or

into many thousands of tons. Nevertheless the amount of synthetic fertilizer available for Indian agriculture is much less than the actual requirement so that our crop yields are no more than one-third or one-fourth of those in other countries.

Investigations made during the last 30 years have shown that apart from the ten major elements known to be essential for plant growth (carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, iron and magnesium) there are several others which are also important although needed only in minute quantities. Of these copper, boron, silicon, chlorine, manganese, zinc and molybdenum are specially noteworthy. A dieback disease of citrus, occurring in Florida, California, South Africa and other places, has been traced to copper deficiency ; lack of boron causes serious damage to apple crops and sugar beet ; absence of manganese often gives rise to chlorosis ; and zinc deficiency is known to cause a "rosette" of apples, "mottle-leaf" of citrus and "yellows" of walnuts.

Quite a few of the deficiency diseases can be cured just by spraying a suit-ably prepared solution of the element in short supply, or adding it to the soil, or by inserting a pill into a bore-hole in the trunk of a tree. However, simple soil applications do not always give the desired result. For example, the chemical analysis of a soil may show adequate amounts of iron and yet the plants grown on such soil show unmistakable signs of iron deficiency. This may be due to the unavailability of the iron because of a high pH or some other factor. To give an example, if too much lime is put on a soil the pH may go up to 7, 8, or more, with the result that phosphates and some micronutrients become unavailable. The chlorotic appearance thus caused is designated as lime-induced chlorosis. Under such circumstances providing more iron to the soil is of no use because this will be thrown out of solution just as promptly as that which is already there. Spraying is better, or one may try to make the soil slightly acidic. It has also been found possible to keep the iron soluble by using ethylenediaminetetraacetate. This forms a soluble complex with the iron which now becomes available.

The trace elements are in the nature of catalysts or parts of enzyme molecules which are essential for the normal metabolism of plants. Serious disturbances may result in their absence. The internal cork of apples and heart-rot of sugar beet have been found to be due to boron deficiency and can be prevented by the application of sodium borate (borax) to the crop. The mottle-leaf of citrus can be cured by applications of zinc. Large tracts in New Zealand, where the sheep and cattle suffered from a "pining sickness", have been rendered useful by the addition of cobalt, and in southern Australia a large desert area has been converted into good agricultural land by applications of minute amounts of sulphates of zinc and copper. In south-east Australia a small addition of copper not only enabled the growth of oats, wheat and lucerne but also improved the wool of the sheep grazing on the fodder. In southern Australia homeopathic doses of molybdenum enabled miles of worthless land to "blossom as a rose".

It is to be noted that while the trace elements are absolutely essential, even a small excess may do harm to plants and poison them. This is of course also true of the major elements although in a different way. For example, if a farmer applies too much nitrogen fertilizer to strawberries he causes the carbohydrates present in the plants to combine with the nitrogen and the fruits may become tasteless owing to lack of sugar. On the other hand, with leafy vegetables like spinach and chenopodium considerable quantities of nitrogenous fertilizers can be used with advantage for under their effect the plants produce lush, dark-green leaves and tender stems, which are much richer in proteins and therefore possess a higher food value. With wheat an excess of nitrogenous fertilizer produces weak

stems that are likely to cause the plants to fall over or "lodge". The dosage as well as the time of application of the fertilizer have, therefore, to be studied in each case.

There is another point that has to be kept in mind. Plants are rather indiscriminate and pick up many more chemicals from the soil than they need. Even gold may be present in certain plants to retard the development of the cattle that feed on plants grown on such soils. Iodine, although not needed by plants, is quite essential for the health of animals and human beings. When the water and the plants of any area lack iodine, this has to be supplied from outside.

It is interesting to note that the presence of certain other elements in the soil may be deleterious rather than beneficial to plants or to animals, as the case may be. Among these are arsenic, selenium and thallium. The so-called 'alkali disease' is a good example of this kind. About the middle of the 19th century it was observed that animals in some areas of western USA became debilitated and often died in large numbers. It was later found that (a) certain plants absorb selenium from the soil and the forage produced in such areas contains small quantities of this element ; (b) even one part per million of selenium may kill animals ; and (c) such soils become dangerous in those years when there is not enough rainfall or irrigation water to wash out the selenium.

Mention may also be made here of the recent development of soil conditioners which, if they can be produced cheaply, may step up yields appreciably. One of the problems of agriculture is to maintain a good soil texture to permit the absorption of water and air and to prevent hardening of the soil. A good soil texture can be achieved by the addition of organic manures. Where these are insufficient, a pound of krillium may be used in place of a hundred or one thousand pounds of compost. Krillium has no plant nutrients but is remarkably effective in improving the physical texture of heavy soils.

PLANT PROTECTION

While superior breeds of plants under proper conditions of irrigation and soil fertility will naturally give higher yields, plants like animals suffer from many kinds of diseases and it is important to maintain them in good health in order to obtain the highest yields from them. That fungi, bacteria, viruses and insects take a heavy toll is now well known, but a few examples may not be out of place.

The potato blight (Phytophthora infestans) caused havoc in the middle of the nineteenth century. In 1845 a terrible wave of the blight swept the potato fields from Norway to Bordeaux reaching the extent of a national calamity. In Ireland the disease was noticed in the last week of August and rapidly developed in an intensity unequalled in any other country. In 1846 it was worse, in 1847 milder, but bad again in 1848. The great famine which followed the disease had repurcussions which lasted for many years. The population of Ireland, which was eight millions in 1841, had lost a million by death and immigration by the next census in 1851. The impoverished country was unable to support even these reduced numbers and there was a steady stream of emigration which lasted throughout the century.

Another fungus disease (Hemileia vastatrix) wiped out the coffee plantations of Ceylon towards the latter part of the 19th century. Due to the attack of this rust the coffee bushes were so seriously affected that they became unprofitable and coffee is no longer grown on a commercial scale in Ceylon. Recently, the blister blight of tea, caused by Exobasidium vexans, has appeared in south-east Asia and threatens to be another serious menace. The "Panama disease" caused by

the algae, or some other unusual sources. Now, while there are some portions of the earth's surface which are lying uncultivated, these are in the jungles of the tropics, or in desert lands, or in places which are too cold and inhospitable. To use these areas we require not only much technical skill but also a great deal of money. We could irrigate the Rajasthan desert, we could freshen sea-water and use it on land, and we could perhaps cause artificial rain. These are no doubt all possibilities but they are not likely to materialise in the immediate future.

The first and most important source of additional food is, therefore, from the existing crops themselves whose yields can be greatly increased through several methods such as (a) planting of superior seed ; (b) application of artificial fertilizers ; and (c) control of weeds, pests and parasites. In fact the yields of cereals in India are only about one third of those in the advanced countries. It is also possible that the culture of such microscopic organisms as yeast and *Chlorella* may provide us with new and cheap sources of proteins. We shall discuss some of these one by one.

THE GENETIC IMPROVEMENT OF PLANTS

A good many of the economic plants of the world have been subjected to extensive selection and hybridization resulting in an improvement in yield of as much as 40 per cent in many cases. This may be illustrated by referring to the sugarcane on which some significant work has been done right in India.

Although many varieties of cane are grown in the tropics, only three types are important in India. The first or noble canes (*Sachharum officinarum*) are grown in tropical and subtropical India as well as Indonesia, Hawaii, West Indies and Mauritius. They are very rich in sugar and are also suitable for chewing purposes owing to their low fiber content and thin rinds. They, however, need a comparatively equable climate and very careful cultivation combined with liberal manuring and irrigation. Another disadvantage is their susceptibility to a number of diseases and pests. The second type, called medium canes (*S. barberi*), represent a class which grows well under subtropical conditions. Besides northern India they are also cultivated in southern Africa, Louisiana, northern Australia and parts of China and Japan. These are thinner than the noble types and have a lower sugar content. In addition their rinds are thicker and they have more fibre so that they are less suitable for chewing purposes. However, they possess other desirable characters like a deeper and more vigorous root system and narrower leaves which render them resistant to drought and frost. They also show greater resistance to certain pests and diseases than the noble canes. Finally there is a wild species, *S. spontaneum*, of which there are many varieties thriving in various parts of the world even under conditions of the greatest neglect. These are resistent to all kinds of adverse conditions such as drought, water-logging and soil salinity. In many parts of India the plant is an obnoxious weed which infests large areas of the soil. It has very thin stems with hard rinds and extremely narrow leaves. The structure of the leaves, stems and roots shows various adaptations which make the plant resistant to most of the pests and diseases affecting the cultivated canes.

C. A. Barber and T. S. Venkataraman were among the first to engage themselves in producing new and improved types of cane combining the "blood" of all the three types. When the wild cane is crossed with the noble cane, this step is called nobilisation. Frequently two or three such nobilisations are necessary before the desired result is obtained. By an appropriate programme of triple

hybridisation between the wild, medium and noble canes, carried out at Coimbatore and later in the other cane growing areas of the world, it has been possible to evolve types with satisfactory juice value as well as the capacity to grow under adverse conditions. The Coimbatore hybrids are now being grown all over India and have resulted in a 50 per cent increase in yield over the figures obtained for the older varieties.

Valuable work of similar nature has also been done on wheat by B. P. Pal and on other crops by various plant breeders and geneticists in the country, but this needs to be strengthened and carried out on a much larger scale. A good example of the results of such work is the hybrid maize industry of the USA which has in itself raised the yields of maize by 30 per cent.

SOIL NUTRIENTS

Of the ten major elements required by plants nitrogen, potassium and phosphorus are the most important and out of these the one which is most often in short supply is nitrogen. Sir William Crookes was so impressed by the need of fixed nitrogen for stepping up the yields of wheat that he wrote as follows in 1899 :

"It is of urgent importance today, and it is a life and death question for generations to come. I mean the question of food supply. Many of my statements you may think are of the alarmist order ; certainly they are depressing, but they are founded on stubborn facts. They show that England and all civilized nations stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. Land is a limited quantity, and the land that will grow wheat is absolutely dependant on difficult and capricious natural phenomena. I am constrained to show that our wheat-producing soil is totally unequal to the strain put upon it. After wearying you with a survey of the universal dearth to be expected, I hope to point a way out of the colossal dilemma. It is the chemist who must come to the rescue of the threatened communities. It is through the laboratory that starvation may ultimately be turned into plenty."

He further said : "The fixation of atmospheric nitrogen therefore is one of the great discoveries awaiting the ingenuity of chemists. It is certainly deeply important in its practical bearings on the future welfare and happiness of the civilized races of mankind. This unfulfilled problem, which so far has eluded the strenuous attempts of those who have tried to wrest the secret from nature, differs materially from other chemical discoveries which are in the air, so to speak, but are not yet matured. The fixation of nitrogen is vital to the progress of civilized humanity. Other discoveries minister to our increased intellectual comfort, luxury, or convenience ; they serve to make life easier, to hasten the acquisition of wealth, or to save time, health, or worry. The fixation of nitrogen is a question of the not far-distant future. Unless we can class it among certainties to come, the great Caucasian race will cease to be foremost in the world, and will be squeezed out of existence by races to whom wheaten bread is not the staff of life."

Fortunately the challenge was met. In 1913 the German chemist Fritz Haber found the way to fix atmospheric nitrogen and humanity was saved !

During recent years many factories have been started in India for the manufacture of fertilizers. The production of ammonium sulphate began in Mysore in 1938 and in Kerala in 1947. The factory at Sindri was started in 1951, another was started at Nangal in 1961, and a third at Rourkela in 1962. Their total annual production of ammonium sulphate and superphosphate runs

In this respect certain microscopic algae present some advantages over our ordinary crop plants. Several of them can be cultured on a large scale, but so far no systematic study has been made to find the most suitable types for food production. One of these, *Chlorella pyrenoidosa*, has received considerable attention in the USA ; in Japan they have experimented with *C. ellipsoidea* ; and in England with *C. vulgaris*.

Chlorella is unicellular. Being only $3-10\mu$ in diameter it appears as an insignificant little blob under the microscope. However, the cells multiply very quickly (once every 12 hours) and require only simple inorganic salts for their growth. Normally the alga manufactures carbohydrates but if supplied with nitrogenous salts and other minerals and given plenty of light, it shows an amazingly high protein content which may go up to as much as 58 per cent on a dry weight basis. If the nitrogen is reduced and the plants are given plenty of carbon dioxide, good light and a long period of growth, the proportion of fat goes up to 86 per cent of the dry weight.

This is important because the present food shortage of the world is not so much in terms of carbohydrates but in fats and proteins. Another significant point is that the fats as well as the proteins of *Chlorella* are of high quality from the point of view of human beings. The fat is probably as good as that from soya bean and the protein contains all the ten essential amino acids. All the important vitamins are also present. It has been estimated that a one acre plot of *Chlorella* could give an annual yield of 20 tons of dry protein and 2 tons of fat.

Unfortunately the cost of growing *Chlorella* is prohibitive at present. Although the major nutrients such as carbon dioxide, water and nitrogen salts are not expensive and there is plenty of sunlight in the tropics, it still needs quite a set-up and high technical skill to grow the plants on a large scale. It is of course possible that there are other algae which are superior to *Chlorella* and these can be further improved by selection, hybridisation and mutation. It may be recalled that the present strains of *Penicillium notatum* are many times more productive than the original strain of Flemming. And what has been done with *Penicillium* can also be tried with *Chlorella* and other organisms. What is expensive today may become cheap tomorrow! This kind of research must, therefore, be pursued actively.

For the manufacture of proteins and fats, we must also consider another well known microscopic organism, the yeast. Yeast cells have no chlorophyll and are therefore unable to live on a purely inorganic medium. However, their requirements are very modest and they thrive without difficulty on ammonium salts and molasses. It has been estimated that a 500 kg animal produces only 0·5 kg of protein in 24 hours while the same weight of *Torulopsis* yeast produces more than 1000 kg of protein in the same time. Thus an yeast factory has a considerable advantage over a meat producing farm. Further, it is possible to substitute molasses by hydrolysed sawdust and pulping waste. Just as *Torulopsis* is suitable for producing proteins, so two other types—*Endomyces* and *Rhodotorula*—have proved to be very satisfactory for the production of fats.

In conclusion, we may say that man does not live by bread alone and yet it is hard to stay alive without it. In the means of transport and communication and in methods of waging war modern man has made truly phenomenal advances over his ancestors. Can we say the same thing, however, about agriculture and the one essential thing called food ? In this respect we are still bound

to the past, for most of our crop plants had already been brought into cultivation four thousand years earlier.

What is the reason for this slow progress in a sphere which is of such importance to our lives and which threatens our very existence ? The only answer is that biological phenomena are far more complex than physical and chemical phenomena and it takes more time, energy and resourcefulness to understand them. Also, the budgets for biological laboratories are the lowest, their equipment is old and antiquated, and in the name of economy the axe is always ready to fall upon them.

THE SCARCITY OF BIOLOGISTS

Even more distressing than lack of funds is the comparatively smaller number of biologists in the country. Any one who has served as a member of the science admission committee of a university must have noticed that students keep physics and engineering as their first choice, then come chemistry and medicine, while biology and agriculture come last.

India is predominantly an agricultural country and yet we suffer from a constant scarcity of food. This is not because the Indian farmer is less industrious than his western counterpart or because the land is poor but simply because we have not used scientific methods in our agriculture and are still bound to the hoary past in our techniques of crop production. Dr D. S. Kothari, Chairman, of the University Grants Commission rightly remarked : "Modern agriculture is really applied biology. It is necessary in relation to our plans of agricultural development and increased food production that the effort on agricultural education should be very much more than what it is today." Another distinguished physicist J. D. Bernal writes as follows in his book entitled 'Science in History' : "In the near future, given an end to the cold war, the rewards of biology are bound to lead to its very rapid increase. — . . . biology offers problems of great complexity where ingenuity is at a premium. —Even the simplest of them (living organisms) surpasses a thousand or a million—fold in absolute complexity the most complicated systems devised by man. —Biology cannot in the nature of things be as simple as physics or even chemistry, since it includes these subjects in itself. Nor can it be expressed in the language of precise mathematics, because it has too great a multiplicity to describe by enumeration. —The problems of an increasing population and of static or decreasing food supplies can be solved only by an active and advancing biology. —The very successes of physics and chemistry have ensured that biology should now present the key problems of the whole of natural science, offering a challenge to the understading of the world in which we live, which will call for far more extensive and at the same time better coordinated efforts than all those which science has dealt with in the past".

What is the cause of this scarcity of men in biology in spite of the over-powering role that this subject has played and will play to a still greater extent in the future ? In final analysis they can perhaps be traced to three sources. The first of these is the lack of consideration and respect shown by the government to the tillers of the soil. Even the public is much more impressed by a textile or steel factory than by the farm. While paying top service to the food problem, there has been no real attempt to get at the root of it. The second is the absence of any instruction in biology in many of our schools. At present the majority of the schools in India give no integrated picture of science but teach only physics and chemistry. The result is that the young boy or girl, who has never been exposed to biology, naturally prefers to ask for admission to a

Fusarium cubense, a soil organism, has endangered the banana industry in Jamaica and Central America resulting in the abandonment of banana cultivation on thousands of acres. In India the three wheat rusts have been causing an annual loss of 60 million rupees.

Returning to the potato blight, its repeated ravages led to a testing of all known varieties of potato for resistance against it and expeditions were organised by several countries to obtain a number of wild varieties from the original home of the potato in South America. As the result of inter-crosses between these varieties it has been possible to create new types which show considerable resistance to the blight as well as to a number of virous diseases. What has been done with the potato is also being attempted with many other crops and today plant breeders and plant pathologists are working in close cooperation to develop new varieties of plants which are not only superior in yield but are also resistant to most of the diseases which generally affect them.

The use of fungicides like copper sulphate, formaldehyde, copper carbonate and organic mercurial dusts has made it possible to control many seed-borne diseases, and there has been a similar improvement in the development of spraying materials. While Bordeaux mixture is still very popular, the substitution of commercial lime-sulphur, wettable sulphur and other substances has greatly increased the effectiveness of control.

The value of D.D.T. in controlling insect pests is now well known to every one. A more recent development is the possibility of applying a chemical to the roots or some other aerial part of a plant or injecting it into its tissues so that they become distasteful to the insects without affecting the usability of the produce. It is, in some respects, parallel to the vast developments which have taken place in human and animal pathology, for exemple the use of quinine, atebrin and paludrin in malarial prophylaxis and treatment. The most useful chemical, explored in this connection, is octamethyl pyrophosphoramide, called Schradan or Pestox 3. If applied to the soil or introduced into irrigation water, it makes plants toxic to sucking insects for 3-6 weeks. Another similar chemical is bis-isopropylaminofluorophosphine oxide or Isopestox. This is toxic for only 7–8 days so that crops can be treated with it almost up to the time of harvesting.

Systemic chemicals have also been tried during recent years for the control of fungal diseases. Earlier work was directed mostly against diseases of woody trees as in the case of the Dutch elm disease, but some nitropyrazoles when injected into tomatoes have been found to delay the appearance of lesions of *Alternaria solani*. This is a wide open field for future research.

CONTROL OF WEEDS

A farmer's life is a constant battle with weeds, and until recently mechanical cultivation, which is both arduous and costly, was the chief method for getting rid of them. The discovery that certain synthetic hormones will distroy some kinds of plants and leave others relatively unharmed has proved to be of the utmost importance in this connection. When applied at concentrations of 0·0001 to 0·01 per cent they stimulate growth, but at concentrations of 0·1 to 0·2 per cent they seriously damage the aerial parts of plants and eventually kill them.

The chemical used most in the UK is 2–methyl 4–chlorophenoxyacetic acid (methoxone or MCPA), and in the USA it is 2,4–dichlorophenoxyacetic acid (2,4–D). Most broad-leaved plants are readily affected while the grasses and

cereals remain unharmed. Due to this selective action, lawns and fields containing cereals may be treated with safety. In Hawaii 2,4-D has also been found useful in controlling the weeds of sugarcane plantations. Complementary to methoxone and 2,4-D, is trichloracetic acid (TCA) which is effective against grasses and has therefore been used very successfully in fields of beet, flax and certain legumes to kill the grass weeds inside them.

It is important to note that the drifts from herbicidal sprays and dusts applied from the air may sometimes cause serious damage to adjacent crops. In the USA where herbicides are used extensively, this has given rise to serious problems and even to cases of litigation. Sprays should therefore be applied only when there is little movement of the air; the spray bar should be as near the target as possible; and the spray should be at a rather low pressure.

Two or more herbicides may sometimes be mixed to produce a combination effect or the herbicide may be mixed with an insecticide or a nutrient spray. The advantages are (a) saving of time and money, (b) less mechanical damage, (c) and control of a wider range of weeds. The disadvantages are that (a) it is difficult to arrive at the correct timing of a combined spray ; and (b) the action of one constituent may impair or nullify the effect of the other by forming insoluble salts or by preventing the absorption of some elements.

SOME SHORTCOMINGS OF OUR EXISTING CROP PLANTS

Besides improving our existing crop plants and taking proper care of them, there is also another approach to the problem which may be illustrated by giving an example. If an engineer had charge of engines which did not produce a sufficient amount of energy and he were asked to produce more power, what could he do about the matter ? In the first place he can perhaps construct a larger number of engines of the same type. If he has more brains, he can try to improve the performance of the existing engines by lubrication and minor adjustments. If he is really clever, he could try to make an entirely new design. What we have considered so far are methods of the second order.

Before we enter into a further consideration of this point, it is well to understand what are the defects, if any, in the existing photosynthetic engines. In the first place most of our crop plants convert only a very small percentage of the solar energy falling on them into organic material. Much of the light falling on a leaf is reflected back, or passes through the leaf, or is absorbed by the tissues to serve as heat energy. Normally no more than 1·0 per cent is utilized in photosynthesis. The very nature of plants makes them ineffective for a full utilisation of sun's energy. They have a slow rate of growth and it is only for a short period that they are at the peak of their activity. In wheat, for instance, during the first six weeks only about one fourth of the maximal leaf surface is developed. During the next two weeks an additional one fourth is formed. It is only in the ninth or tenth week that the full leaf surface is developed. After this the plant is active for another three or four weeks and is then ready for harvesting. Thus the process starts at zero and is slowly built up until maximum efficiency is reached. This lasts for a short time only after which the event comes to a complete stop and must be started anew by sowing a fresh crop. Further, while we ask the wheat plant to synthesize sugar and starch for several weeks, eventually we eat only the small fraction stored in the grain. In mango it is only the flesh of the fruit that is edible, and the stem, leaf and root are of no value for this purpose. In other words, only a part of the organic material synthesized by the plant can be eaten and the rest is wasted from the point of view of nutrition.

course in physics or chemistry and considers biology as an unfamiliar and perhaps more difficult science where it is almost impossible to secure the high marks obtained in physics and mathematics and where the chances of good employment are less certain. The third reason is the rather uninspiring teaching of biology in our educational institutions. What is taught at present is a travesty of the subject. This last ponit needs to be considered in a little more detail.

One factor, which makes the present courses in biology rather dull, is that their contents are mostly or entirely descriptive. While the morphological part must still form the basis of biology and has to be done well, this cannot be the only thing and physiology, ecology, genetics, and the role of biology in human life are subjects which also demand adequate attention. A large fund of biological information acquired during the present century finds no mention in most of our texts, nor do they provide any information about the interdependence of plants and animals. Problems like what happens in photosynthesis or respiration and how living organisms respond to external and internal stimuli elicit greater interest in the minds of students and are more important than learning the characters of a family of plants or describing the pectoral girdle of frog. It would be appalling if a school student should get the impression that biology is nothing more than sketching the shapes of leaves and bones or just a system of naming plants and animals in unfamiliar language.

CONCLUSION

Although out of all sciences biology has the greatest applications in everyday life, not all the work in this field need be inspired by selfish motives alone. That is not the way science has progressed in the past or will progress in the future. Basically science is a quest for truth and many persons are motivated to take up biological research just to satisfy their curiosity. It is out of such work that the whole field of antibiotics emerged. Similarly the chapter on plant hormones emerged from Darwin's (1880) question as to why plants bend towords light. There are still many such questions demanding explanation. For example, in spite of many years work we do not quite know how water rises to the tops of such tall trees as the *Sequoia* and *Eucalyptus*. Why do the leaves of *Mimosa pudica* collapse when touched ? Why do leaves turn yellow and red in the month of October in western countries and in February in our climates. Why is it that in the mango and in *Amherstia* it is the new leaves that show the red colour ? How does a bat see its way in darkness ? Why do fishes and birds travel for hundreds of miles and then return to the same spot which they had left earlier ? Can life be created in the test tube ? Can fertilization and embryo development be completed in the higher plants and higher animals in vitro ? Can the nitrogen-fixing bacteria which live in symbiotic association with the roots of leguminous plants be made to attach themselves to our cereals and to other plants so that we do not have to worry too much about adding nitrogenous fertilizers to the soil ? What is the key to heredity and can we direct the changes in the molecules of heredity in accordance with our wishes ?

Ladies and Gentlemen, I am now through with my talk but before I close I wish to emphasize that biology is concerned not only with plants and animals but with man himself. If we ask ourselves : What is it that endures best ? A great city ? Or a large industrial state ? Or the best built steamships ? Or buildings of cement and iron ? Or great bridges, minarets and forts ? The answer is a definite no ; it is men and women of ideas who are the most important. Even if a city has only a few mud huts but a few great men and women, it is in fact the greatest city in the whole world. In living memory we saw that although Gandhiji

lived in the Sabarmati Ashram in Ahmedabad and the Harijan Colony in Delhi, his presence continued to attract visitors from all parts of the world.

How are we to get these great men and women ? That is the toughest problem before humanity. It is rendered extremely complex because while it is not too difficut to measure the disease-resisting properties of sugarcane, or the milking qualities of a cow, or the fleetness of a race-horse, it is not the same with the measurement of spiritual and intellectual values. If we want a disease-resisting wheat or an intelligent sheep-dog, we breed them, and we know that we cannot get them in any other way. We cannot hope to obtain them by manuring, watering and generously tending a wild grass, or by careful feeding and training of a mongrel dog. The study of human heredity teaches us the same lesson. There are families in man in which some special ability is inherited from generation to generation. There are others which show the inheritance of some defect like haemophilia, colour blindedness, tendency towards diabetes, and so on. Even the pattern of baldness is hereditary. Obviously then, if we are to improve the human race we must make a conscious effort in that direction. Unfortunately marriages among humans are arranged on an emotional rather than a biological and genetical plane. There are, however, a few things that can perhaps be undertaken right away. People suffering from a stock with a marked hereditary deffect such as insanity, epilepsy or mental weakness have no right to reproduce and hand on this defect to the next generation.

We must also examine our social laws to make sure that they do not favour the less gifted, less able, and less energetic members of the community while discouraging reproduction of those who are better endowed. While we must do our best for all our fellowmen, we dare not sacrifice the future for the present. It is dangerous for a nation to breed chiefly from its inferior stocks. And yet that is what seems to be happening at the moment. While the more intelligent and educated are aware of the dangers of over-population and consequently tend to marry late and have fewer children, the others consider children to be just an act of God and are undisturbed by this steady deterioration of the germplasm. If this goes unchecked, during the next fifty years we shall have a much larger number of the feeble-minded and much fewer pupils of scholarship ability. This genetical erosion threatens all countries but particularly those which are overpopulated.

How are we going to stop it ? Before we act we need a greater knowledge of human biology. Which traits are inherited and which are not ? Which are the most desirable qualities, which are not so desirable but can be tolerated, and which are the ones that we root out at all costs ? The second point is to see that no bright child is deprived of education and progress just because of lack of money. Poverty has sometimes been a bar to higher education and it is our duty to see that this does not remain so in future. We must pick out the most talented boys and girls as early as we can spot them and give them our best attention in all possible ways.

All this requires a lot of work. Before we think of space ships and rockets and travelling to the moon let us consider what we can do right here with the plants, animals and human beings on this planet. We need not try to climb on the bandwagon of other nations simply because certain types of research appear to be more fashionable than others. We have our own problems to solve—problems of food, health and population—and must see that there is a proper distribution of the scientific effort in India. If we are to avoid a serious crisis 20 or 25 years later the present imbalances must be corrected and we must redress this persistent neglect of the life sciences so that our children and grandchildren do not blame us for their sufferings. We cannot wait for this. We must do it now and immediatety. Jai Hind !

PRESIDENTIAL ADDRESS

COMPARATIVE STUDIES ON CARBON NUTRITION OF SOME ISOLATES OF *COLLETOTRICHUM GLOEOSPORIOIDES* PENZ.

By

Professor R. N. TANDON, M.Sc, Ph.D., D.I.C., F.A.Sc., F. N. I., F.N.A.Sc.

Head of the Botany Department, University of Allahabad, Allahabad.

I am deeply conscious of the honour which the Council of the National Academy of Sciences has chosen to confer upon me by asking me to preside over the Biological Science Section at the Thirty Fourth Annual Session. I am fully alive to my shortcomings and I hope that in your generosity you will overlook my faults.

During the last thirty five years, I have been interested in nutritional studies of pathogenic fungi causing leaf spot diseases as well as the storage diseases of fruits and vegetables. A number of research students have been associated with me and with their help some interesting data has been collected. Space and time will not permit detailed discussion but it is intended to place before you the behaviour of a number of isolates of *Colletotrichum gloeosporioides* in the hope that this will stimulate further research.

The importance of nutritional studies of fungi has been recognised for a long time. Apart from the fundamental knowledge which they impart, such studies are essential for understanding the general behaviour of the organisms. The information can prove helpful in explaining the pathological behavior of fungi. In fact many control measures against severe diseases, specially those caused by soil fungi, can be explained on the basis of physiological and nutritional studies. In recent years some methods for prevention of diseases by soil amendments have been suggested but this could only be possible after thorough investigation of the nutritional requirements of the organisms responsible for them.

Some literature on physiological studies, of fungi is now available but unfortunately in most cases the results are restricted to one or two organisms only and even for them the diverse experimental conditions employed by different investigators have left little room for comparison. This difficulty is of considerable importance on account of the changing responses of living forms. The progress has been slow on account of wide differences exhibited by closely related forms. Attempts have been made to generalise but they have always failed because of fluctuating physiological response of the same species isolated from different sources. Inspite of great care which has been taken by different workers, the biochemical data has remained vague and occasionally it becomes difficult to explain contradictory results obtained by different scientists.

Colletotrichum gloeosporioides was isolated from the leaves of *Prunus persica* Stokes (Isolate 1) ; *Punica granatum* Linn. (Isolate 2) ; *Polyscias balfouriana* Linn. (Isolate 3); *Nephalium litchi* Camb. (Isolate 4) ; *Carissa carandas* Linn. (Isolate 5) ; *Eucalyptus robusta* Sm. (Isolate 6) and *Bougainvillaea glabra* Choizy (Isolate 7). The detailad studies of Isolate 1 was carried out by Tandon and Varma (1962), Isolate 2 by Tandon and Chandra (1962a–1962b), Isolate 3 by Chaturvedi (1961), Isolate 4 by Prasad (1963) and Isolates 5, 6 and 7 by Ghosh (1964). Monosporic cultures were

prepared by the usual methods and stock cultures were maintained on Asthana and Hawkers medium A * The same medium and its modifications were used for detailed nutritional studies. For eliminating the influence of pH on growth and sporulation the most suitable value was determined and adjusted in each case.

Carbon and nitrogen are most important elements needed by fungi because they go to form the main components of living matter—the protoplasm. The comparative selectivity of different carbon and nitrogen compounds of various organisms has been reported by numerous investigators.

In order to have uniform and comparable data the amount of carbon present in the basal medium was calculated and its quantity in different substances, was so adjusted as to contain equivalent amount of carbon. Extra pure chemicals were used. Flasks of equal size containing 25 ml. of autoclaved medium were inoculated with mycelial discs of equal size. The fungal mat was harvested on previously dried Whatman's filter paper No. 42. They were subsequently dried at 60°C for 3 days and were then weighed. Three replicates were taken for each series. Chromatographic technique has been used to determine the pathway of utilization of various compounds. Except for slight modification the method suggested by Ranjan *et al.* (1955) has been followed.

The effect of different pH on growth and sporulation is given in Table 1.

TABLE 1

Showing the effect of different pH on growth and sporulation of different Isolates of *Colletotrichum gloeosporioides.*

pH	Growth of different Isolates					
	Isolate 1	Isolate 2	Isolate 3	Isolate 5	Isolate 6	Isolate 7
1·0	X	O	X	X	X	X
2·0	P	P	O	O	O	O
2·5	P —	X —	X	P **	P **	P **
3·0	P *	P *	P *	P ****	P ***	P ***
3·5	X	X	X	M ***	P ****	P ***
4·0	M **	M ***	P ***	G ***	G ***	M ***
4·5	G ***	X	G ***	G **	G **	G **
5·0	G ***	M ****	G ****	G **	G ***	G **
5·5	G ****	G ****	G ****	G ***	G ****	G ***
6·0	G ****	G ****	G ****	G ****	G ****	G ****
6·5	G ****	G ***	G ****	G ****	G ***	G ****

*Glucose 5 g., potassium nitrate 3·5 g., dihydrogen potassium phosphate 1·75 g., magnesium sulphate 0·75 g., agar 20 g. and water 1000 ml.

	Growth of different Isolates					
pH	Isolate 1	Isolate 2	Isolate 3	Isolate 5	Isolate 6	Isolate 7
7·0	G ****	G *	G ***	G ***	G ***	G ***
7·5	G ****	G *	M **			
8·0	M ****	G *	P **	M **	P *	M *
9·0	M ****	G –	P *	P *	P *	P –
9·5		G –				
10·0	M ***			P *	P –	P –
11·0				P –	P –	P –
12·0				P –	O	P –
13·0				O	O	O

Growth	Sporulation
P = Poor	– = Absent
M = Moderate	* = Poor
G = Good	** = Fair
X = Not studied	*** = Good
O = No growth	**** = Excellent

It is evident that pH 5·5 to 6 were most suitable for all the isolates of *Colletot-richum gloeosporioides* but marked differences in growth as well as sporulation were evident. Only the best pH has been used for detailed comparative studies and hence subsequent variations shown by different isolates were not dependent on this factor.

The influence of various sources of carbon on growth and sporulation of different isolates is recorded in Table 2.

TABLE 2

Showing the growth and sporulation of different isolates of *Colletotrichum gloeosporioides* on various sources of Carbon

Sources of Carbon	Growth of different Isolates						
	Isolate 1	Isolate 2	Isolate 3	Isolate 4	Isolate 5	Isolate 6	Isolate 7
Xylose	G *	P **	P ****	P **	M ****	M ***	P **
Ribose					G *	G *	G ***
Arabinose		P ***	G few	P ***	M **	M *	P *
Rhamnose		M *	P *	P *	P *	P **	P *
Glucose	G –	G ****	G ****	G ****	G ****	G ****	G ****

Sources of Carbon	Growth of different Isolates						
	Isolate 1	Isolate 2	Isolate 3	Isolate 4	Isolate 5	Isolate 6	Isolate 7
Fructose	M –	G **	G ***	G **	G ***	G ****	G ****
Galactose	M –	G ***	P few	P **	G ***	G **	G ***
Sorbose	P –	M ***		P **	P ***	P ****	P ***
Mannose		P **	G *		P *	P *	P *
Sucrose	G ***	G ****	G *	G **	G *	G **	G **
Lactose	P *	P **	M *	P ***	G *	G ***	G ***
Maltose	G *	G ****	G ****	G **	G ***	G ****	G ****
Cellobiose				G ***	G ****	G ****	G ***
Trehalose					G ****	G ****	G *
Raffinose	P **	M ****	G **	G **	G *	G ****	G ****
Melizitose				P **	G ***	G ***	G *
Dextrin		M *	M ***	P ***	G **	G **	G ***
Starch	G *	M ****	G ***	P **	G ***	G ***	G ***
Inulin		M ****	P ***	P ****	P **	P *	P –
Glycogen					G ****	G ***	G ***
Mannitol	G –	G *	G few	G ***	G *	M **	G ****
Sorbitol	G –	G **	G few	P **	M ****	P *	G ****
Glycerol	G –	M ***	G *	P **	G ****	M ***	G ****
Tartaric acid	P **	P *	P *		G **	P *	P ***
Oxalic acid					No growth	No growth	No growth
Malic acid		P *	P –		P **	M **	M ***
Citric acid					M *	M **	G **

Growth
P = Poor
M = Moderate
G = Good

Sporulation
– = Absent
* = Poor
** = Fair
*** = Good
**** = Excellent

The utilization of various carbon compounds may depend either on the ability of the fungus to utilize certain simple forms directly or on its power to convert the complex carbon compounds into simple ones which may be easily assimilated. Many investigators have suggested that the different reactions of various carbon compounds towards a particular organism may be due to structural variation or to difference in configuration of molecules of those compounds. The results may also depend on the difference in the permeability of the cell wall or on the presence or absence of specific enzymes necessary for degradation of the complex compound or on the respiratory steps followed by the substance. Besides these there may be some other factors not understood so far.

It is, however, quite clear that the various substances do not induce the same response from all the isolates. Isolate 1 gave good growth on xylose which supported moderate growth of Isolates 5 and 6. The growth of all the other isolates was poor. The growth of Isolates 5 and 6 on arabinose was moderate but in this case the growth of others except Isolate 3 was poor. Isolate 2 differed from all the others on rhamnose because the growth was moderate in contrast to poor growth of all the others. All had good growth on glucose, fructose, sucrose and maltose except Isolate 1, which had moderate growth on fructose. Galactose supported good growth of Isolates 2, 5, 6 and 7 but it was a poor source for Isolate 3 and 4. The growth of Isolate 1 was moderate. Sorbose was a poor source for all except Isolate 2, which showed moderate growth. Mannose supported poor growth of all except Isolate 3, which had good growth. Lactose was a poor source for Isolate 1, 2 and 4. It supported good growth of others except Isolate 2, which had moderate growth only. Raffinose supported poor growth of Isolate 1, moderate of Isolate 2 and good of all the others. Dextrin was a moderate source for Isolates 2 and 3, poor for Isolate 4 and good for the rest. Starch was good for Isolates 1, 3, 5, 6 and 7, moderate for Isolate 2 and poor for Isolate 4. Inulin was generally a poor source but it supported moderate growth of Isolate 2. Mannitol was good for all except Isolate 6, which had moderate growth only. Sorbitol supported poor growth of Isolates 4 and 6, moderate of Isolate 5 and good of the rest. Glycerol was a poor source for Isolate 4, moderate for Isolates 2 and 6 and good for the remaining ones. All except isolate 5 had poor growth on tartaric acid. Detailed studies with three other acids were confined to Isolates 5, 6 and 7 only. They failed to grow on oxalic acid. Malic acid supported poor growth of Isolates 2, 3 and 5 and moderate of Isolates 6 and 7. Though citric acid was a moderate source for Isolates 5 and 6 but it supported good growth of Isolate 7. These results clearly indicate that the growth of different isolates varied considerably on a large number of carbon sources. Uniform results were obtained only with glucose, sucrose and maltose, which supported good growth in each case. In all other cases the same source was good, moderate or poor for different isolates of *C. gloeosporioides*. Results obtained by Agnihotri (1958) indicated that glucose was not always a good source. It supported only moderate growth of *C. capsici* isolated from *Pothos scandens*. Misra and Dutta (1963) also observed variations in the two isolates of *C. capsici* used by them. The isolate of *C. capsici* used by Thind and Randhawa (1957) as well as by Chaturvedi (1961) showed marked differences with the isolates of Agnihotri or Misra and Dutta. Due to similarity between *Gloeosporium* and *Colletotrichum* some results obtained for certain species of that genus have been compared. Tandon and Agarwala (1956) found glucose to be a moderate source for *Gloeosporium citricolum*. Similarly Grewal (1955) reported that maltose was a poor source for *C. papayae*. It was also a poor

source for *G. citricolum* (Tandon and Agarwala, 1956), *G. musarum* (Grewal, 1955) and a moderate source of *G. papayae* (Grewal 1955). Even sucrose is not uniformly good because it is found to be a moderate source for *G. psidii* (Tandon and Agarwala 1954). Ghosh (1964) has carried out detailed studies of 2 isolates of *C. dematium* and has compared them with the isolate studied by Misra (1960). He has also observed marked differences in the growth of the three isolates of this species. The results indicate that in a number of cases glucose, sucrose and maltose may be usefully employed as a source of carbon even though they may not be the best and some other carbon source may be better. The difficulties, however, increase when sporulation is also taken into account.

It is clearly brought out in Table 2 that the degree of sporulation is not constant on a carbon source, because the same substance may induce very poor sporulation in some isolates and excellent in others. The same table will indicate that the instances of this nature are so numerous that it is not desirable to discuss them here individually. These differences are not correlated with the type of growth because poor, fair, good and excellent sporulation may be asso- ciated with every type of growth.

A clearer picture may be available from data based on chromatographic studies. It may throw light on the pathway of utilization of some complex forms and may also indicate the rapidity with which some of the similar forms could be consumed. The utilization of some monosaccharides by various isolates of *C. gloeosporioides* is recorded in Table 3.

TABLE 3

Showing the number of days taken in utilization of various monosaccharides by some isolates of *Colletotrichum gloeosporioides*

| Monosaccharides | Number of days taken for complete utilization | | | | |
	Isolate 2	Isolate 3	Isolate 5	Isolate 6	Isolate 7
Glucose	6	6	4	5	4
Fructose	7	8	6	5	6
Galactose	8	11	9	11	12
Mannose	11	5	6	5	7
Sorbose	8	–	16	12	14
Xylose	9	5	8	8	8
Arabinose	9	7	8	6	6
Rhamnose	6	8	9	8	8

The above table established that the time taken by different isolates to consume the same substance varied considerably. Ghosh (1964) used double the quantity of carbon but inspite of this his results indicate that the isolates used by him consumed glucose, fructose and mannose much earlier than the other two. The utilization of mannose was much slower in Isolate 2, which consumed galac- tose and rhamnose earlier than others. Isolate 3 used xylose earlier than the rest. Quicker utilization of mannose by Isolate 3 has been used for speculating the cause of its good growth on this substance, but this is not borne out by

subsequent results obtained with Isolate, 6 where the growth was poor inspite of its ability to consume double the quantity within the same period. Similarly even though galactose was utilised slowly but it supported good growth of four and poor of the other two. Thus the time taken in cosuming particular carbon source failed to explain the cause of good or poor growth of the organisms under study. The utilization of various oligosaccharides has also been studied. It was found that all of them used lactose without hydrolysis. Its breakdown products were not traced in any case. It persisted in the medium upto a period ranging from 10 to the end of the incubation period (15 days). Differences were evident between different isolates. A mixture of glucose and galactose supported better growth than lactose. Sucrose, maltose and raffinose were hydrolysed to simpler substances. The time taken for their complete hydrolysis differed in different isolates. Isolates, 2, 6 and 7 hydrolysed sucrose in 3 days, while Isolates 3 and 5 took 4 days. The time taken in complete utilization of the hydrolytic products (viz., glucose and fructose) also varied. Isolate 2 consumed both on the same day but Isolates 3, 6 and 7 used glucose a day earlier than fructose. Two other oligosaccharides were produced during the utilization of sucrose by Isolates 2, 5, 6 and 7 but Isolate 3 developed only one oligosaccharide. Rf values of the oligosaccharides produced by different Isolates were not quite similar. Bealing and Bacon (1953) have suggested that the transference of fructose residues to suitable acceptors with the help of enzymes (β-fructofuranosidase) is responsible for the synthesis of intermediate oligosaccharides during the hydrolysis of sucrose. In all cases oligosaccharides disappeared from the medium before the maximum dry weight was produced. It appears that they were hydrolysed to constituent monosaccharides and were then utilized. Maltose was hydrolysed to glucose in all except Isolate 7. The time taken in complete hydrolysis varied from 4 days (Isolate 3) to 6 days (Isolate 6). It is interesting to note that Isolate 7 did not consume all the maltose upto 7th day and in this case the hydrolytic product (viz., glucose) was not detected in the medium. Maltotriose was synthesized by Isolates 2 and 3 and two oligosaccharides (Rf 0·18 and Rf 0·10) were produced by Isolates 5, 6 and 7.

Trisaccharide raffinose contains galactose, glucose and fructose units. When it is acted upon by glucosidase it breaks into sucrose and galactose. Tandon and Chandra (1962) reported that melibiose, fructose and galactose were detected during the utilization of this substance by their organism (Isolate 2). They suggested that it was first hydrolysed to melibiose and fructose ; subsequently melibiose yielded glucose and galactose. The glucose formed in the medium was simultaneonsly consumed. It was, therefore, not detected. They also observed that a mixture of glucose, fructose and galactose was better than raffinose. Ghosh (1964) also found that its ultilization was slow. It was used up by Isolates 5 and 6 in 10 days and Isolate 7 in 9 days. He also found that only one intermediate product (galactose) could be detected. The time of its appearance and persistance varied in the three isolates.

The effect of different nitrogen sources on some of these isolates has also been studied in detail and differences between the various isolates are equally common. Those results also fail to explain the cause of such differences.

The data presented here clearly reveal wide variations between 7 isolates of *Colletotrichum gloeosporioides*. Such differences are equally common in different species of this genus as well as in other fungi, which have been studied so far. The cause of such variation is not yet understood though it has been suggested

by various workers that it is due to 'specific' nature of fungi. It only hides our ignorance and indicates the need of more research, which may ultimately help to explain such behaviour.

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PRESIDENTIAL ADDRESS

By

Professor K. BANERJEE, D.Sc., F.N.I., F.I.A.S., F.N.A.Sc.,

Director, Indian Association for the Cultivation of Science, Calcutta

MR. CHAIRMAN, FRIENDS AND COLLEAGUES,

I am extremely grateful to you for the honour that you have shown to me by asking me to preside over the Physical Sciences Section of the National Academy of Sciences. I know my limitations and crave your indulgence for my shortcomings which will certainly be many.

Large-scale development of the Physical Sciences in India is of recent origin. But it is very remarkable that the realisation of the great need of scientific education and research came as early as a century ago when Dr. Mahendralal Sircar conceived the idea of founding an institution where nationals of India could work to extend the bounds of scientific knowledge just like the scientists of advanced nations. It was about the end of the nineteenth century that a beginning in effective scientific research in India by Indian scientists began when the works of Sir J. C. Bose and Sir P. C. Ray received international recognition and created inspiration among Indians. A great stimulus came when Sir Asutosh Mookerjee started the University College of Science, in which he collected some people of uncommon talents. Following the Calcutta University some of the other universities also gradually gave more and more stress on research and a number of good research centres developed. Inspite of this impetus to scientific research, the equipments, that the scientists could get were extremely meagre, and the number of research scholarship or other research posts were extremely few. Most of the University teachers had so heavy routine teaching duty that it was only by extremely overworking themselves that they could carry out any worthwhile research work.

These conditions of extreme Government apathy continued until independence was attained. But, however, inspite of the small number of research workers as well as the paucity of facilities, the record of Indian scientists during the period had no mean achievement in quality. Raman effect, Bose statistics, Saha Equation, Krishnan's Crystal Magnetism may be specially mentioned among a host of brilliant contributions from India during that period.

India acquired independence sixteen years back. Our late great Prime Minister declared time and again his great concern for scientific development and research. The expenditure on scientific research from the national exchequer has increased several hundred folds. Of course, in comparison with the more advanced countries the expenditure on scientific research is still insignificant. Even the ratio this bears to the total national budget is much lower than in those countries. Well disposed as the rulers of our country are to scientific research it may be expected that this gap will soon be filled up and the expenditure on scientific research will be further increased manifold.

Before launching upon any programme of large scale increase in expenditure, it is worthwhile to examine whether the results that have been already

attained are commensurate with the money spent on them. If not, we have to examine why it is not, so that the mistakes if there be any may be avoided in future planning.

Without going into the details of assessment, one thing is apparent that the number of scientists carrying on research work and consequently the number of research publications have increased enormously during these years. So although increase in volume of research work may be commensurate with the increased expenditure, we do not have the satisfaction that Indian work of this period has extended the frontiers of scientific knowledge to such extent as was done in the earlier period though in limited scales.

The qualitative assessment of research work is a difficult task. However, outstanding results if any are generally so well known that assessment does not require any difficult probe. Work of the type of Raman effect, Bose statistics or Saha equation which open up new lines of research or cause landmarks in the existing lines are easily distinguished. Work that gets a substantial place in text books and review articles and are referred to extensively in papers by other schools of research without adverse criticism are also criteria for high standard of research work. If we compare the sixteen years prior to the 2nd world war to the sixteen years of independent India, what do we find ? We cannot mention any work during the latter period which can come under the first category. As regards the second category, without going into any details we can say that inspite of the small number of research workers during the earlier period, there have been a much larger volume of work passing the criterion mentioned above than during the latter period. This is a matter that should make us think very seriously if we are to regain our lost position in the scientific map of the world.

The reason for the deterioration is a complex one and there must be a great multiplicity of causes contributing to this state of affairs. It is not possible for me here to go into all the causes, but I like to mention some experiences of one who had the opportunity of carrying on research work during both these periods in the hope that they may be of some help in such an investigation.

Before the second world war and after, there has been a tremendous technological progress in Europe and America. This progress has affected the physical sciences in all aspects. The apparatus needed for research work in physics or chemistry during the twenties of the persent century even in the advanced laboratories of Europe and America could be fabricated in laboratories with the help of not-too-big workshops attached to them. This has enabled the talented among the physicists and chemists to make in their own laboratories equipments needed for front-line research work. Since the fourth decade of the century physical sciences have entered upon an era when apparatus started to become more and more complicated at an enormously rapid rate, requiring high order of technological skills to fabricate them. This has been possible through collaboration between the scientists and the technological people of those countries. In India technological development has been extremely poor and contact between the scientists and technologists is practically absent. Thus fabrication of research apparatus has become difficult in laboratories.

In the National laboratories, it has been attempted to obviate this difficulty by importing complicated apparatus from abroad. That procedure has two difficulties apart from the question of expenditure of foreign exchange. Firstly, there is a considerable time lag between the first construction of an apparatus for a research purpose and its construction being taken up by a firm for commercial

exploitation. Due to this time lag any important fundamental result cannot normally be expected to be derived out of it. It remains useful only for routine type of investigations. The other difficulty is that when any part of it goes out of order, it is extremely difficult to set it right, and many valuable research equipments have become idle in India due to this cause. So in order to carry out front rank experimental research, the research scientist should have facilities to carry out in practice any original practical idea that he can think about. This point of view has been completely neglected during the past years. The workshops attached to the University laboratories have remained in practically the same conditions as they were during the twenties of the present century. Even at the national laboratories which had opportunities of free flow of money and foreign exchange, people did not think of constructing their research equipments there. The salaries of technical staff in these workshops have been really miserable and higher technical staff in general do not exist. Unless this state of affairs is removed India cannot expect to make any first rate contribution in the physical sciences. Our loboratories must be supported by good workshops in which there should be strong teams of technological staff on salaries and status comparable to those of the research staff. This is indispensable. Even if it necessitates drastically reducing expenditure on full-proof research equipments imported from abroad. We have fallen behind other countries by these 30 years which can be made up only by a determined effort.

Another reason for the deterioration appears to be our emphasis on the doctorate degree and the number of published papers and not on qualities in assessing our scientists for promotions or higher appointments. This inhibits launching of long term research projects or attacking highly ambitious problems, as by doing so the researcher will be at a great disadvantage compared to others due to his inability to show quick tangible results. So in selecting either for new appointments or for promotions, real merits should be assessed instead of following the mechanical methods of counting the number of publications or degrees. This can be done only by experts in the lines, and not by the usual selection committees consisting of majorities of non-experts. In selecting experts also high scholarship and not high position should be the criterion.

Another important factor that has inhibited front rank research work in our country is the nature of planning of scientific development. Soon after we won our independence, a large number of Industrial Research Institutes were ushered in without any proper background for their existence. The scientists available in India were mostly in the Universities. Their number was not even adequate for the Universities. So when these Research Institutes started there was a paucity of scientists of adequate calibre. The Universities on account of the utter neglect by the Government also deteriorated rapidly in standard. So the scientific manpower with which these laboratories started were not in general equal to the tasks entrusted to them and the position of supply of personnel from the Universities also could not improve. The objectives of the National laboratories were not very clear. Their structures were meant for industrial research, but their contacts with industries were meagre. Industries in India scarcely took advantage of the findings of these laboratories. This is true also for the industries in the public sector. The scientists who manned the National laboratories did not have the proper background for changing over from bias for fundamental research that they received at the Universities to that of industrial research. The set-up was not adequate even for fundamental research, for which the right places are Universities or University type of Institutions, where two-way traffic of ideas between veterans and freshers is possible.

Frustration in our young people has also been a serious contributory cause. In National laboratories there are many instances of publications under a number of authors for each paper. The name of the director being usually a common factor. It cannot be expected that the director being a human being can take part effectively in all those investigations particularly when the major part of his time is taken away by administration, tours abroad and memberships of inordinate number of committees. The young worker whose name comes last is usually the one who does the main work. The recognition that he gets in the scientific circle is inadequate either for his labour or talent. The natural consequence is that he loses interest, and since the main responsibility of the publication devolves not on him but his seniors, there is a danger of his being more interested in supplying data fitting with the whims of the people above him than with the actual experiments. There is thus a possibility of those who are careless about the accuracy of data rising up in positions at the cost of the more scrupulous ones. Causes creating this type of frustrations should be fought against vigorously.

Government of India is launching upon a very good project of creating supernumerary posts in Research Institutes to absorb Indian scientists who are staying in foreign countries and cannot come back to India due to want of suitable positions. This is a very commendable idea, but placing them in National laboratories will create the same difficulties as with the Pool Officers. In the Universities there is an extreme chronic shortage of staff. The student to teacher ratio is fantastically high. Is it not, therefore, much more profitable to have all the supernumerary posts created in Universities or University type of Institution where their foreign training will be fully utilised ?

There has recently been a great lamentation in the speeches of our Government authorities about the migration of Indian scientists to foreign countries. The Government is trying to make all out efforts to bring them back and create difficulties in the path of those wishing to go abroad although they might not need any expenditure of foreign exchange from the country. There have already been intense propaganda from the Indian Embassies among the Indian scientists working abroad as reported by those who have recently returned, that jobs are waiting in India for them. Many of those who have returned to India on such assurance are facing extreme frustration and are trying to go back. The institution of Pool Officerships, however, has to some extent enabled them to stay on but failed to remove that frustration. This has, however, acted as a very great incentive for a large number of scientists to come back to India.

I do not know whether this matter has been given as serious a thought as it deserves. The problem should have been studied systematically as to why is it that a very large number of scientists do not desire to come back. On personal discussions with a large number of them I found that unplanned bringing back of the scientists may produce greater harm than good to the country. I propose to put forth some of the points that have cropped up as a result of these discussions and I shall be glad if they are seriously considered by our authorities controlling scientific research.

If we analyse the stages of education at which our scientists proceed abroad, we find that the number in the pre-M.Sc. stage is small compared to the higher stages. This is mainly due to the fact that the pre-M.Sc. students have to arrange for their expenses to be sent from India, involving large amount of foreign exchange. Most of them belong to highly rich community. Considering the wastage

of foreign exchange on this count there has recently been great restrictions on the issue of foreign exchange to such students and so their sponsors must have sufficient influence on the Government as well for the puprose. In many cases on account of limited accommodation for M.Sc. admission in India, students go abroad because they do not get chances of higher studies here. Normally they are no problem as the influence that helps them to study abroad is also able to place them suitably in India after their return. They generally come back but not before spending a lot of foreign exchange.

Scientists with only Master's degree are not yet in great demand in Industries in India. Of course there are enough appointments as teachers in colleges and higher secondary schools, but the remunerations and prospects are not attractive enough to keep them satisfied. A few are fortunate enough to get into Atomic Energy Establishment, Research Laboratories of Universities or other Institutes. The more enterprising out of the remaining, can get such opportunities abroad in which they can maintain themselves while receiving research training. Most of them leave the country because the Universities, the Research Institutes and post-M.Sc. training centres do not have enough capacities to absorb them. Occassionally there are talented people among them, as due to defective methods of selections in organisations in India, talented people are occassionally left out.

The number of scientists who get opportunities of research training in India has, however, increased considerably in recent years although they are still very inadequate for absorbing majority of the qualified scientists. But the positions in which they may be absorbed after good research training and having doctorate degrees are still very inadequate. So what happens is that those who are not absorbed easily here try to secure post-doctorate fellowships or other positions abroad, where demand for trained scientists far exceeds the supply. This tendency for going abroad is further accentuated by the fact that usually our selecting authorities put a great premium on foreign degrees and training.

These scientists who were practically unwanted in India receive very good facilities for research work and find themselves particularly in U. S. A. in great demand. Many of them are able to do good work and find some sort of status in the scientific world. The rest also fare much better than they would have done in India, due to much better facilities available abroad. At the same time they are occassionally prone to form exaggerated ideas about themselves in comparison with the scientists working in India, on the basis of their successes there. They get also accustomed to conditions of work which are completely different from those in India where redtapism, difficulties of procuring equipments etc. prevail. Many of those among these scientists who come back to India, stay for some time and return to U. S. A. as they do not find either jobs suitable to their training, or have to work under people whom they consider as inferior to them as scientists or because of the conditions prevalent regarding facilities. The question of high salary prevalent in U. S. A. may also be a factor in some cases but in my consideration this factor is not of much significance.

The problem now is whether it is necessary for us to bring back those scientists to India and if so how could we do so profitably. We have seen before that the National and Defence laboratories in the nature of things have to develop in specialised lines and whenever any scientist who has the odd chances of fitting in there is very welcome. They should be brought back and if posts are not available they may be kept in Pool or may be given supernumerary appointments. But in the majority of cases it will not be so. Our Universities are running with insufficient teachers. Is it not proper for the Government to make more funds

available to them for absorbing at least the better section of the scientists abroad and since the Universities are receptacles of all diciplines of science, the question of fitting in does not arise. The country will be benefited by them for although they might not get the opportunities of carrying on the high class of research work that they had been doing abraod, they will have the satisfaction of being able to raise the standards of University teaching in their motherland for the benefit of the future generation. For the rest I do not think any useful purpose is served by inducing them to come back to India. It will actually be doing them harm as they will be deprived of the facilities for making valuable contributions to science that they had been doing and the country also is not prepared enough to derive any benefit from their scientific abilities. After all science is universal. A discovery in fundamental science made in U. S. A. or in India does not make much of a difference for the progress of human scientific knowledge. By keeping a scientist idle in India we are depriving mankind of the contributions hat he could have made by staying abroad.

For the complete utilisation of all the scientific talents of India, therefore, a programme for better teaching of science has to be inaugurated, from the school stage. Science teachers in colleges or higher secondary schools should receive nearly as renumerative pays as in Universities or National Laboratories so that the scientists are attracted to the teaching jobs instead of leaving the country. The teacher to student ratio should be increased so as to provide for individual attention. Researches in National Laboratories should be restricted to Applied research and to obtain the best results, they should be intimately associated with the industries. Industries should also be made to contribute to the cost for maintaining the National Laboratories. Universities should be helped to develop into great centres of fundamental research. Money spent there should not be grudged as they are the hopes for the future.

SECTION OF PHYSICAL SCIENCES

ABSTRACT OF PAPERS

1. The role of lauryl di-ethanolamide as a polarographic maximum suppressor.

WAHID U. MALIK AND PURAN CHAND, *Chemical Laboratories, University of Roorkee, Roorkee.*

The influence of lauryl di-ethanolamide (LDA), non-ionic surfactant, on the polarographic maxima of Ni^{2+}, Pb^{2+}, Co^{2+}, cadmium iodide complex, copper succinimide and copper biuret complexes has been studied and its superiority over anionic soaps established from the polarographic data. The results also indicate that the amount of the soap required to suppress the positive maxima is larger than for the negative maxima.

Unlike the anionic soaps, the concentration of LDA is independant of pH of the medium. The results have been discussed in the light of the information obtained from the electro-capillary curves. The c.m.c. values of the LDA have been found by this method in the presence of different electrolytes and are of the order 10^{-5}M.

2. Influence of anionic and cationic dyes on the sol-gel transformation of silicic acid sol.

WAHID U. MALIK AND IQBAL A. KHAN, *Chemical Laboratories, University of Roorkee, Roorkee.*

The influence of dyes on the gelation of silicic acid sol have been studied with the help of viscometric, pH –metric and conductometric methods. The results indicate that the time of gelation decreases in presence of basic dyes and increases with acid dyes. The results have been interpreted in the light of the colloid-chemical behaviour of the respective dyes.

3. On the development of unsteady boundary-layer theory.

KRISHNA LAL, *Lecturer in Mathematics, Engineeing College, Banares Hindu University.*

In this paper, I have studied the development of unsteady boundary-layer theory when the velocity potential of flow is of the form $U(x, t) = U_0(x) e^{\pm nt}$. It is based on the work of Lord Rayleigh (2) and Schlichting (3) for the oscillatory non-steady boundary-layer. The equations of non-steady boundary-layer, have been used to discuss the development of boundary-layer theory for the present type of flow. In § 3 interesting result regarding the velocity at the outer edge of the boundary-layer has been obtained. It is shown that a potential flow which is an exponential function of time is not inducing a steady, secondary motion at a large distance from the wall as a result of viscous forces.

[49]

4. A theorem on Hankel transform.

P. N. Rathie, *Department of Mathematics, Faculty of Engineering, University of Jodhpur, Jodhpur.*

The object of this paper is to establish a theorem on Hankel transform. The theorem is used to evaluate certain infinite integrals involving products of Bessel and Gauss's hypergeometric functions. Some interesting particular cases also mentioned.

5. On the Preparation and Physico-Chemical Properties of Anils. Condensation of some Aromatic Amines with Phenylglyoxal.

Wahid U. Malik, D. R. Gupta and C. L. Taploo, *Chemical Laboratories, University of Roorkee, Roorkee.*

Some new anils have been prepared by condensing phenylglyoxal with aniline, *p*-chloroaniline, *o*-, *p*-nitro anilines *o*-, *p*-toluidines, and *α*-, *β*-naphthylamines. They have been characterized by preparing *p*-nitrophenyl hydrazones, 2 : 4- dinitro phenyl hydrazones, semicarbazones and oximes. The oximes give colour reactions with a number of metal ions and offer a possibility for being used as analytical reagents.

6. Chemical Examination of the Seeds of *Litsea-consimilis*.

D. R. Gupta and S. K. Garg, *Department of Chemistry, University of Roorkee, Roorkee.*

Litsea-consimilis, a plant belonging to lauraceae family, grows wildly on the hilly tracks of Nainital. The seeds (diam., 0·8-1·25 cm) have a soft, brownish black odorescent pericarp (27·4%) and two brown coloured cotyledons inside. Like other lauraceae plants, its seeds are of medicinal importance and are locally used in the treatment of rheumatism and skin diseases. Chemical investigation on the seeds of this plant does not appear to have been undertaken so far. The present communication describes the chemical examination of the seed fat of this plant. From the Kernels of the seeds of *Litsea-consimilis*, a yellowish brown coloured oil (50·55%) has been obtained, which consists of the glycerides of capric acid (1·7%), lauric acid (59·08%), myristic acid (11·48%) and oleic acid (27·74%).

7. Some properties of a generalization of Lommel and Maitland transforms 11.

Ram Shankar Pathak, *Department of Mathematics, Banaras Hindu University, Varanasi.*

In a recent paper I have given a generalisation of the Lommel transform (Hardy, 1925) and generalized Hankel transform (Agarwal, 1950) in the form

$$f(x) = \int_0^\infty (xy)^{\frac{1}{2}} J_{\nu,}^{\mu}(xy) \, g(y) \, dy,$$

and obtained an inversion formula for the same. The present paper aims to develop the theory of this generalized transform, by establishing certain theorems which are analogous to the corresponding theorems in generalized Hankel trans-from theory (Agarwal, 1951).

8. Some integrals involving G- function whose argument is a power of the variable.

P. K. SUNDARARAJAN, *Department of Mathematics, S. F. S. College, Nagpur.*

In this note we have evaluated the following infinite integrals by the method of operational calculus. These integrals include as special cases when $r = 1$ some known integrals.

$$(1) \quad \int_0^\infty x^{-\rho}\, K_{2m}\,(2\sqrt{ax})\quad G_{p,q}^{l,n}\left(x^r y \left|\begin{array}{c} a_1, \cdots \cdots \cdots, a_p \\ b_1, \cdots \cdots \cdots, b_q \end{array}\right. \right)\, dx$$

$$(2) \quad \int_0^\infty x^{\rho-1}\,(x+\beta)^{-\sigma}\quad G_{p,q}^{l,n}\left(x^r y \left|\begin{array}{c} a_1 \cdots \cdots \cdots, a_p \\ b_1 \cdots \cdots \cdots, b_q \end{array}\right. \right)\, dx$$

$$(3) \quad \int_0^\infty x^{-\sigma} E\left(\mu, \delta :: \frac{a}{x}\right)\quad G_{p,q}^{l,n}\left(x^r y \left|\begin{array}{c} a_1, \cdots \cdots, \cdots \cdots, a_p \\ b_1 \cdots \cdots \cdots \cdots, b_q \end{array}\right. \right)\, dx$$

9. Some infinite integrals associated with hypergemetric functions.

H. M. SRIVASTAVA, *Department of Mathematics, University of Jodhpur, Jodhpur.*

Many well-known integral formulae are exhibited as special cases of an infinite integral involving generalised hypergeometic function. A known case of reducibility of Appell's double hypergeometic function of the second kind and a linear relation between Appell's F_4 and a Horn's function are deduced. A correction is pointed out in Feldheim's formula expressing an infinite integral involving product of two Laguerre polynomials.

Single integral representations for Lommel function and product of two $_1F_1$'s, and also of two Bessel functions, are given. And an infinite integral involving a terminating $_pF_p$ is evaluated in terms of gamma functions.

10. Differential Equations of Lauricella's F_D.

H. M. SRIVASTAVA, *Department of Mathematics, University of Jodhpur, Jodhpur.*

In the course of a study of the 'four-term' differential equation

$$\sum_{\lambda=0}^{3}\ (-x)^\lambda\, f_\lambda\ (\delta)\, z = 0 \qquad \left(\delta = x\frac{d}{dx}\right)$$

the author in collaboration with S. Saran [Ganita, **15** (1964) No. 2] established the theorem that a function z which satisfies the partial differential equations

$$\theta_i f(\delta) z = p_i x (\theta_i + a_i) g(\delta) z \qquad (i = 1, 2, 3)$$

where $\theta_i = p_i \dfrac{\partial}{\partial p_i}$ and $\sum_{i=1}^{3} \theta_i = \delta$, is a solution of the ordinary equation

$$\delta f(\delta) f(\delta - 1) f(\delta - 2) z$$
$$- x \left[p_1 (\delta + a_1) + p_2 (\delta + a_2) + p_3 (\delta + a_3) \right] f(\delta) f(\delta - 1) g(\delta) z$$
$$+ x^2 \left[p_1 p_2 (\delta + a_1 + a_2) + p_2 p_3 (\delta + a_2 + a_3) + p_3 p_1 (\delta + a_3 + a_1) \right] f(\delta) g(\delta) g(\delta + 1) z$$
$$- p_1 p_2 p_3 x^3 (\delta + a_1 + a_2 + a_3) g(\delta) g(\delta + 1) g(\delta + 2) z = 0.$$

Also the linear ordinary differential equation associated with Lauricella's triple series

$$F_D (a ; b_1, b_2, b_3 ; c ; px, qx, rx)$$

was shown to possess one hundred and twenty solutions in terms of F_D, there being no logarithmic solution at any of the five singularities. In this paper the author discusses in details two interesting exceptions to the general statement that in the neighbourhood of a regular singularity at the origin the equation can be solved in terms of the functions F_D themselves.

11. Certain integral Repesentations for Modified Bessel function of Second kind.

D. C. GOKHROO, *Department of Mathematics, Malaviya Regional Engg. College, Jaipur.*

In the present note, we have evaluated some infinite integrals involving the product of Bessel function of first kind and generalized hypergeometric functions, such as S_4 and MacRobert's E-Functions whose variables are of the type $(p^2 + t^2)$, where $arg|p^2| < \pi$, with the help of Operational Calculus. The integrals have been evaluated by the application of a theorem on Laplace Transform given earlier by me [1964]. In the obtained integrals, when p tends to zero, we get known result of Erdelyi, A. A few integral representations for the Modified Bessel function of Second kind $K_\nu (x)$ have also been obtained as their particular cases, which are believed to be new.

12. A Study on the Formation of Complex Compound between Bivalent and Univalent Salts VII.

A. K. AGRAWAL, *Chemical Laboratories, Malviya College of Engineering, University of Gorakhpur, Gorakhpur.*

A preparative study of the system : $Hg(CN)_2 - KX - H_2O$ (X = CNO or Se CN) has been carried out and complexes of the type $KHg(CN)_2 X$ have been isolated and found to remain unchanged on recrystallisation.

13. Polarographic Determination of Silver and Mercury.

G. S. DESHMUKH, A. L. J. RAO* AND N. C. V. ACHARYULU, *Division of Analytical Chemistry, Banaras Hindu University, Varanasi.*

An indirect method for the determination of silver and mercury is given Silver and mercury are precipitated by the addition of an excess of selenious acid or sodium selenite. The precipitates are filtered and in an aliquot of filterate the amount of selenium is determined polarographically, in 1M ammonium acetate. From the amount of unreacted and total selenium, the amount of selenium reacted with the metal and thence the amount of metal is determined. Twenty part per million of silver and mercury can be determined with less than one per cent error.

Presen address : Department of Chemistry, Punjabi University, Patiala.

14. Some Properties of Solutions of Differential Systems.

M. RAMA MOHANA RAO, *Department of Mathematics, College of Engineering, Osmania University, Hyderabad.*

In this paper, we shall discuss the ultimate boundedness and asymptotic stability of a differenital system with respect to its approximate system.

15. UV Radiation induced synthesis of amino acids from a mixture of gases in presence of water.

O. N. PERTI AND H. D. PATHAK, *Chemical Laboratories, Th. D. S. B. Government College, Naini Tal.*

Methane, ammonia, carbon dioxide, nitrogen and hydrogen were bubbled through water contained in a transparent quartz vessel kept under an ordinary mercury quartz lamp. After 5 hours co-chromatographic analysis of the solution through which these gases were continuously passed indicated formation of amino acids. Experiment was continued for 5 hours a day for 10 days and amongst the amino acids formed glycine, alanine, lysine, arginine, amino butyric acid, tyrosine, tryptophane, aspartic and glutamic acid could be identified. Gases used in these experiments were those generally believed to be present in the prebiological reducing atmosphere of the Earth, and, therefore, the results obtained throw light on the abiogenic formation of amino acids in the pre-actualistic atmosphere era of the Earth when there was no ozone layer to cut off the ultraviolet component of sunlight.

16. Kinetics of oxidation of N-Propyl Alcohol by potassium persulphate in Aqueous solution—Part I.

S. S. BISHT AND S. P. SRIVASTAVA.

The Ag^+ catalysed oxidation of n-propyl alcohol by potassium persulphate follows a first order behaviour in presence of a high concentration of K_2SO_4 but

3 mols of $K_2S_2O_8$ are needed for the oxidation of 2 mols of alcohol. The first order rate constant is dependent on the initial concentration of alcohol upto a certain concentration after which it becomes independent of alcohol concentration and the rate constant is also dependent on initial concentration of $K_2S_2O_8$; it decreases with an incrase in $K_2S_2O_9$ concentration. These facts suggest that the mechanism of the reaction is rather complex. The temperature coefficent is 1·67 and the energy of activation is 10·058 K cal. per mol. The frequency factor and the entropy of activation are $2·956 \times 10^2$ litre mols sec^{-1} and $-47·32$ E. U. respectively.

17. A class of integral equations involving Jacobi polynomials as kernel.

K. N. SRIVASTAVA, *Department of Mathematics, M. A. College of Technology, Bhopal (M.P.).*

Inversion integrals for singular integral equations involving Jacobi polynomials as kernel have been obtained with the help of fractional integration. In the end a solution of an integral equation has been obtained in an elementary way by using Rodrigue's formula for Jacobi polynomials.

18. Electrometric Titrations of Bentonite with different exchange cations.

WAHID U. MALIK AND G. C. GUPTA, *Chemical Laboratories, University of Roorkee, Roorkee.*

Potentiometric and conductometric titrations of Bentonite (hydrogen, calcium, magnesium and iron forms of the clay) have been carried out both in the aqueous and non-aqueous media using caustic soda and calcium hydroxide as the titrants, with both glass and hydrogen electrodes. With the different exchange forms of the clays two inflexion points are obtained both in the aqueous and the non-aqueous media, but with the original clay or with the mixture of different exchange forms of the clay the number of inflexion points is increased from four to five and three to five respectively in passing from the aqueous to the non-aqueous media. The pK values as obtained from the titration curves were found to fall under two categories (*i*) calcium and magnesium clays ; (*ii*) hydrogen and iron clays giving almost similar pK values. The titrations with Ca (OH)$_2$ gave different pK values from those realized in the case of caustic soda. The cation exchange capacities (c. e. c.) were different for the first inflexion point in the case of the two alkalies but were almost the same for the second inflexion point. The cation exahange capacities of the clays were in the order.

$$\overset{+}{H} > \overset{+++}{Fe} > \overset{++}{Mg} > \overset{++}{Ca}$$
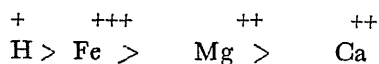
19. Electrometric titrations of metal hydrous oxide Sols and their mixtures in aqueous and non-aqueous Media.

W. U. MALIK, S. K. SRIVASTAVA AND G. C. GUPTA, *Chemical Laboratories, University of Roorkee, Roorkee.*

Potentiometric titrations of alumina and ferric oxide sols have been carried out, separately as well as with the mixtures of the two sols in aqueous and non-

aqueous media using both the glass and hydrogen electrode. From the inflexion points it is concluded that the alumina sol behaves like a dibasic acid in the alcoholic medium but no change from monobasic to dibasic character is observed with the ferric oxide sol. The results of potentiometry also find confirmation in the conductometric data on the titrations of the two sols. With alumina—ferric oxide sol mixtures two inflexion points are realized with mixtures containing upto 20% alumina. Below this ratio only one inflexion point is obtained. Aging of the sols as such or of their mixtures does not influence the titration data.

Data on Pallmann Effect studied with different concentrations of the sols also indicate a difference in behaviour as far as measurements in the two media are concerned. $\triangle$ pH for the two layers is higher in the alcoholic than in the aqueous medium. Elimination of the "Levelling Effect" by the addition of non-electrolytes has been considered as one of the important factors influencing the electrometric behaviour of these sols.

20. Co-ordination compounds of Rhodium (III) with substituted biguanides.

A. I. P. SINHA, *Department of Chemistry, L. S. College, Muzaffarpur.*

The co-ordinating behaviour of N–diethylbiguanide and N–phenylbiguanide with rhodium (III) has been studied. N–diethylbiguanide co-ordinates with Rh (III) quite readily but, unlike the simple biguanide complexes, the salts with common anions appear to be extremely soluble Solid complexes could be isolated only with large anions, dithionate and dichromate. However, like the simple biguanide complexes, these can also be represented by the general formula [Rh (RbigH⁺)₃]X₃, where RbigH = $C_6N_5H_{11}$ and X an univalent anion or equivalent thereof, and the complex dithionate is a light cream, diamagnetic solid, suggesting an octahedral configuration with $d^2 s p^3$ bonding. Phenylbiguanide appears to be less reactive, no complexes of the above type being obtained. Only one solid complex corresponding to the formula, Rh_2 (PhenylbigH⁺)₃ Cl₅ could be isolated. This behaviour is in confirmity with the decreased stability of the phenyl-biguanide complexes of other metals as well.

21. The generalized problem on two fixed centres.

U. N. SINGH AND R. K. CHOUDHARY, *Department of Mathematics, L. S. College, (Bihar University), Muzaffarpur.*

In this paper the motion of a celestial body under the gravitational field of two fixed centres has been discussed. The equations of motion have been taken in Delaunay Variables and then by having determined the characterstic exponents; an adelphic integral is found. This adelphic integral has helped me to get a complete integration of the motion.

22. Second order perturbations in Polar co-ordinates of an artifical satellite in the gravitational field of an oblate spheroid.

RAM BINOY SINGH AND RAMKISHORE CHOUDHARY, *Department of Mathematics, L. S. College, (Bihar University), Muzaffarpur.*

In this paper the motion of an artificial satellite in the gravitational field of an axially symmetric oblate spheroid has been studied in Delaunay variables. During this study perturbation up to the second order is taken into account and Von Zeipel's method has been exploited. Lastly the radius vactor r and the longitude u for the artificial satellite have also been calculated by the same method and with perturbation stated above.

23. Studies in ferric phosphate sol—Part 1

N.R. DHAR AND R.C. KAPOOR, *Sheila Dhar Institute, University of Allahabad, Allahabad.*

Ferric phoshate sol was prepared by adding to a solution of ferric chloride, a solution of potassium phosphate with constant shaking when the slight precipitate formed is peptised with excess of ferric chloride. The sol was allowed to dialyse. Portions of sol were taken at different stages of purity and its various properties *viz.* surface tension, viscosity, conductivity and stability were studied. Observations show that in the initial stages the surface tension is smaller but as dialysis progress the surface tension increases until it attains a static value.

Viscosity has been found to increase rapidly with the progress of dialysis.

The specific conductivity at the initial stage is very high due to the presence of stabilising ions. With the progress of dialysis as these stabilising ions are removed the conductance decreases.

With the progress of dialysis the stability decreases and finally a gel is formed.

24. Influenc of nitrogen fixing algae and chlorella on nitrogen fixation in Gangapur soil in presence and absence of organic matter.

N. R. DHAR AND S. K. ARORA, *Sheila Dhar Institute, University of Allahabad, Allahabad.*

Experimental results obtained show that when soil organic matter undergoes slow oxidation in air, in presence of moisture, there is a small increase in the nitrogen content of the system.

When carbonaceous substances like wheat straw, peat sawdust, etc. mixed with soil and allowed, to undergo slow oxidation by frequent stirring, there is appreciable nitrogen fixation more in light than in dark.

In sets inoculated with algae some saving of carbon and a small increase in nitrogen is observed in light but no significant difference in dark. It is interesting to note that the saving of carbon in sets inoculated with *Chlorella* is greater than that in sets inoculated either with *Anabaena* and *Tolypothrix* which are nitrogen fixing but *Chlorella* cannot fix atmospheric nitrogen.

There is appreciable increase in nitrogen contents over the control set, in the sets inoculated with *Tolypothrix* and *Anabaena* the increase being greater in the case of *Tolypothrix* than that of *Anabaena*.

25. Influence of coal and basic slags in improving the nitrogen status of Gangapur soil in presence and absence of algae.

N. R. Dhar and S. K. Arora, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

Experimental results show that when lignite or Assam coal is mixed with soil in a finely divided condition, lignite is more readily oxidised than Assam coal. These results, therefore, are in support of the view that Assam coal which is bituminous is more ancient and dehydrated than lignite.

There is appreciable nitrogen fixation more in light than in dark when Tata Basic Slag or German Basic Slag are added to the system supplying available phosphate, potash and trace elements, thereby improving the fertility of the soil.

In the sets inoculated with algae there is slight increase in nitrogen contents over the control set in light, though no significant difference in the dark.

The oxidation of lignite is slower than wheat straw and peat.

The results obtained prove that substances like coal, lignite, can undergo slow oxidation at ordinary temperature when mixed with soil more so in light than in dark.

From our results, it can be concluded that peat, lignite etc., which are not used as fuels at present, can be profitably utilized for improving the nitrogen status of the soil.

26. Phosphate adsorption and other investigations with colloidal ferric hydroxide.

N. R. Dhar and K. S. Bhattacharya, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahadad.*

The object of this study is to determine the adsorption of different soluble phosphates by colloidal ferric hydroxide in order to elucidate the role of ferric hydroxide in the fixation of phosphates. Because of their high specific surface soil colloids, both mineral and organic, are active centres of adsorption. Other properties of colloidal ferric hydroxide including surface tension, viscosity, precipitation values of phosphates and other anions, pH etc. have been investigated.

It has been found that the values of adsorption of phosphate ions are much higher than those of oxalate, sulphate, ferricyanide, dichromate ions.

The values of adsorption of P_2O_5 from different soluble phosphates by colloidal ferric hydroxide are in the following order when the same initial concentration of P_2O_5 is taken :

$$H_3PO_4 > NH_4H_2PO_4 > (NH_4)_2 H PO_4 > NaH_2PO_4 > KH_2PO_4 >$$
$$Na_2HPO_4 > K_2HPO_4 > (NH_4)_3PO_4 > Na_3PO_4 > K_3PO_4.$$
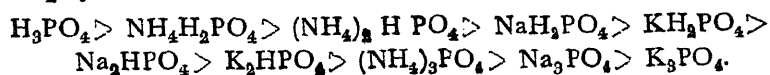
It has been found that P_2O_5 adsorbed from phosphoric acid is 0·7346 millimoles/gm Fe_2O_3 whereas it is 0·6338 millimoles/gm. Fe_2O_3 for $NH_4H_2PO_4$. The plot of concentration $C/x/m$ against C for phosphoric acid gives a straight line except at low and high concentrations. It has also been found that with increasing purity of the sols adsorption goes on decreasing and at very high purity of the

sol, phosphate adsorption is very small. It has been found that ferric hydroxide sol has greater adsorption of P_2O_5 from every soluble phosphate than that of freshly precipitated ferric hydroxide. This is mainly due to the charge on the sol.

We have also determined the precipitation values of different soluble phosphates and other common anions like SO_4'', C_2O_4'', Cr_2O_7'' etc. within a fixed period and that with increasing purity and hence the decreasing charge on the sol, precipitation values are greatly diminished.

The surface tension of sols at different stages of dialysis has also been determined. There is an intial decrease in its value and then it goes on increasing with greater purity of the sols.

Viscosity of the sols goes on increasing with increasing purity of the sols. The values of from Einstein's and Guth-Simha's equations have also been found. Specific conductivity of the sols decreases with increasing purity and that it increases with higher temperatures. Specific conductivity goes on decreasing with dilution of the sol whilst pH increases. pH also increases with the purity of the sol.

The average size of the colloidal ferric hydroxide particles have been determined. Its average diameter was found to be of the order of 5.5×10^{-6} Cm or 5.5μ.

27. Influence of calcium carbonate, calcium oxide and defferent Basic Slags on the decomposition of iron and aluminium phosphates.

N. R. Dhar and B. S. Gupta, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

From our investigations it is evident that Indian Basic Slags are more active in the formation of calcium and magnesium phosphates than European Basic Slags like German or Belgium Basic Slags from ferric, ferrous and aluminium phosphates. The decomposition power towards phosphates of iron and aluminium is in the following decreasing order :

Calcium Oxide > Rourkela Basic Slag > Durgapur Basic Slag > Kulti Basic Slag > Tata Basic Slag > Beglium Basic Slag > German Basic Slag > Calcium Carbonate.

This is due to the fact that amount of OH^- ions available from lime is much greater than that from calcium carbonate. The basic slags are intermediate between lime and calcium carbonate. Further it has been observed by us that magnesium, present in basic slag, also plays an important part in the decomposition of iron and aluminium phosphates with the formation of magnesium phosphate.

28. Influence of Basic Slags on the decomposition of Water-hyacinth (Eichhornia crassipes).

N. R. Dhar and B. S. Gupta, *Sheila Dhar Institutee of Soil Science, University of Allahabad, Allahabad.*

It has been observed that when Water-hyacinth (*Eichhornia crassipes*) mixed with half amount (by weight) of any basic slag—low or high grade basic slag, and left for decomposition for a period 50 to 60 days with regular aeration, there is

appeciable fixation of atmopheric nitrogen which is proportional to the amount of phosphorus present in slag. In this manner a well balanced manure is obtained. Light has been found to increase the fixation of atmospheric nitrogen. This balanced manure has been found to be compact and can easily be transported and utilized in crop production.

29. Effect of different Basic Slags on the mixture of Press-mud and Molasses.

N. R. DHAR AND B. S. GUPTA, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

It has been observed that a mixture of press-mud and molasses in the ratio of 25 : 75 weight when mixed with 50% powdered basic slag by weight of the press-mud and molasses, a well balanced manure is formed within 40 days. Further is has been noted that the amount of phosphorus, present in basic slag, and light absorption play an important role in the fixation of atmospheric nitrogen. These balanced manures contain 28 to 38 lbs. N, 34-40 lbs. K_2O and 50 to 160 lbs P_2O_5, 460-513 lbs CaO and 26-40 lbs. MnO per ton and are very useful for the crop production.

30. A mixture of coal and Basic Slag produces a very good compost with organic matter.

N. R. DHAR AND B. S. GUPTA, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

From a large number of experiments, it has been observed that the composting of Water-hyacinth or municipal waste or any other organic matter when carried on by mixing finely divided coal and basic slag, low or high grade, improves the nitrogen status and humus content of the compost. This type of balanced compost have a residual effect even after the third crop and can be prepared within 80 to 90 days. This compost contains several micro nutrients due to the presence of coal and basic slag and are very productive.

31. Kinetics of decomposition of ammonium nitrite.

N. R. DHAR AND H. K. CHATURVEDI, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

Loss of nitrogen is intimately connected with the process of nitrification of ammonium ions and specifically due to the formation and decompostion of the unstable compound ammonium nitrite into nitrogen and water.

We have observed that the velocity of the decompostion of the ammonium sulphate and sodium nitrite is an unimolecular reaction. Influence of different acids on this decomposition has been investigated and it has been observed that the velocity of the reaction is markedly enhaced by acids and increase of temperature.

32. Influence of different phosphates on the induced oxidation of different nitrogenous substances using manganous hydroxide as an inductor.

N. R. Dhar and H. K. Chaturvedi, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

It has been observed that when air is passed through a system containing nitrogenous substances like ammonium sulphate, ammonium phosphate, urea, uric acid and ammonium nitrate mixed with different amount of manganous hydroxide a fair amount of nitrogen is lost in the gaseous state from the system along with the formation of nitrate.

The percentage loss of nitrogen is greatest in the case of ammonium phosphate and least in case of ammonium nitrate. Our results show that the loss of nitrogen and nitrate formation is greater in light than in dark. Phosphates have been found to retard this nitrogen loss.

33. Nitrogen fixation by algae, organic matter and phosphate.

N. R. Dhar and A. K. Rishi, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

Fixation of Nitrogen by *Anabaena naviculoides* organic matter (as wheat straw) and phosphate (as Tata basic slag) in soil rich in humas and phosphate was studied. The influence of light on the fixation of Nitrogen was carefully investigated.

In was observed that *Anabaena naviculoides* fixed small amounts of Nitrogen as compared to the Nitrogen fixed by organic matter and phosphate in the soil. Moreover growth of *Anabaena* was appreciably enhanced in pressence of organic matter and phosphate. *Anabaena* contributed to Nitrogen increase only in the systems exposed to light. The available Nitrogen in the systems containing *Anabaena* was always less than that of the corresponding systems withouts *Anabaena*. There was an increase in the quantity of free amino acids in the systems containing algae.

A marked increase in the available Nitrogen and amino acid content was observed in the systems having organic matter and phosphate, more so in the systems exposed to light. Thus it was concluded from these results that organic matter and phosphate should be incorporated to keep up the Carbon and Nitrogen status of the soils.

34. Retarding influence of algae and phosphate in the loss of nitrogen from soils.

N. R. Dhar and A. K. Rishi, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

The influence of algae, *Anabaena naviculoides* and *Chlorella vulgaris* in presence and absence of phosphate (as Tata basic slag) on checking the loss of nitrogen resulting by the addition of urea and mustard oil cake with the soil, was studied.

Chlorella was more effective than *Anabaena* in checking the loss of nitrogen from the systems to which nitrogenous substances were added—though *Anabaena* is a nitrogen fixer and *Chlorella* is not. Available nitrogen in the algal sets was always less than that of the corresponding systems without algae. An increase in the amount of amino acids was observed in the systems inoculated with algae. Carbon of the soil was preserved by algae—more by *Chlorella* than by *Anabaena*.

Phosphate also retarded the loss of nitrogen. Maximum retardation was observed when algae was inoculated in the phosphated systems—the addition of phosphate facilitated the growth of algae.

35. Retardation in nitrogen loss by organic matter and phosphate.

N. R. DHAR AND A. K. RISHI, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

Retarding influence of organic matter (wheat straw), in presence and absence of phosphate (Tata basic slag) on the loss of nitrogen resulting by the application of urea and mustard oil cake was investigated.

Observations indicated that organic matter appreciably checked the loss of nitrogen, more so when incorporated along with phosphate, into soil. A marked increase in the available nitrogen and amino acid content was observed in the systems having organic matter and phosphate. Hence it can be emphasised that the addition of organic matter and phosphate is essential for the preservation of soil nitrogen and humus.

36. Nitrogen fixation with organic matter and Basic Slags in soils from Unnao.

N. R. DHAR AND R. S. SRIVASTAVA, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

A sample of Unnao soil containing 0·4814% organic carbon and 0·042% total nitrogen when mixed with 2% carbon as leaves and 0·5% P_2O_5 as basic slag shows anx nitrogen content of 0·0702 gm. in light and in dark 0·028 gm. in 180 days. This shows a marked light effect in nitrogen fixation.

37. Influence of different phosphates in the nitrogen transformation during the decomposition of Municipal waste.

N. R. DHAR AND R. S. SRIVASTAVA, *Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.*

When the municipal waste is mixed with different phosphates or basic slags and exposed to air there is appreciable nitrogen increase in the system by fixation of atmospheric nitrogen much more in the phosphated systems than in their absence. After three months good compost rich in total and available nitrogen, phosphate, potash and lime are ready.

38. Hyperfine structure in Electron Spin Resonance of Picryl-N-Amino Carbazyl solutions.

B. N. MISRA, *Department of Physics, University of Allahabad, Allahabad.*

The electron spin resonance absorption study of Picryl-N-Amino Carbazyl in benzene and chloroform solutions at five different dilutions have been made at 9·5 Kmc. At higher dilutions well separated hyperfine components have been observed. The measurement of line width of each hyperfine lines, separations between the lines, and g values have been made. A good fit between the theoretically computed and experimentally observed absorption spectra have been found by assuming that hyperfine lines have equal width, are equally separated and have Lorentzian shape.

39. Broadening of spectral lines in the Microwave and infra red region due to exchange forces.

KRISHNAJI AND SHYAM LAL SRIVASTAVA, *Physics Department, University of Allahabad, Allahabad.*

A theory for the molecular collision cross-section due to the exchange forces has been developed following the Anderson-Tsao-Curnutte's approach. The widths of pure rotatational lines of HCl and OCS broadened by He, Ar and Kr have been calculated taking into account the induction, dispersion and exchange forces operating simultaneously. It is found that the exchange forces are predominant in the line broadening for these molecular interactions. Experimental and theoretical collision cross-sections agree reasonably well, yet the perturber type behaviour of the linewidths still remain unexplained.

40. Dependence of Dielectric relaxation time of nearly spherical Molecules on Viscosity.

KRISHNAJI AND ABHAI MANSINGH, *Physics Department, University of Allahabad, Allahabad.*

The relaxation time of five nearly spherical molecules, nitrobromoform, nitrochloroform, tert-butyl cyanide, trimethylacetaldehyde and tert-butyl amine, has been measured at different temperatures. The molar volumes of all these nearly spherical molecules are approximately equal, but the macroscopic as well as molecular (microscopic) relaxation times do not show linear dependence on viscosity. This suggests that although the molecules may have the same molar volume, they have different volume for dipole rotation. The Cole-Cole distribution parameter comes out to be zero for all these molecules. The free energy of activation for dielectric relaxation process is much smaller than that for viscosity process. The difference is larger as compared to non-spherical molceules. The enthalpy of activation is less than the free energy of activation; consequently the entropy of activation is negative for all the molecules.

41. Solid rotator phase in polar liquids.

Krishnaji and Abhai Mansingh, *Physics Department, University of Allahabad, Allahabad.*

The static dielectric constant of five polar liquids (Nitrobromoform Nitrochloroform, tert-Butyl cyanide, Tri-methylactaldehyde and tert-Butyl amine) having nearly spherical molecules has been measured over a temperature range extending from the liquid state to the solid state. It has been observed that Nitrobromoform and Tri-methyl-acetaldehyde have a solid rotator phase and belong to class II liquids. The dipole rotation of Nitrochloroform, tert-Butyl cyanide and tert-Butyl amine is prevented on solidification and thus belong to class I, liquids. Various methods of classication of polar liquids has been discussed and slight modification to the method suggested by the authours in a previous paper has been made. About twenty four liquids have been examined in the light of present modification in the classification of the polar liquids.

42. Studies in nitrogen transformation when inorganic nitrogenous are mixed with organic matter and phosphates.

N. R. Dhar and Mrs. S. Chowdhury, *Sheila Dhar Institute of Soil Science University of Allahabad, Allahabad.*

Experiments were performed by us to study the effect of mixing glucose and dicalcium phosphate, with aqueous solutions of ammonium sulphate, ammonium nitrate and calcium nitrate containing 0·05% nitrogen under completely sterile conditions.

100 cc. aqueous solutions of the above mentioned compounds were taken in conical flasks containing 2·5 gms. of titania as surface. To these flasks 2 and 6% carbon in the form of glucose were added. To half the flasks 0·5% P_2O_5 as dicalcium phosphate was mixed. All the flasks were sterilised and then half the flasks were covered with thick black cloth and all the flasks exposed to light from a 100 watt electric bulb. A control set of flasks containing only the aqueous solutions of the nitrogenous compounds (0·05%N) was also kept. Analyses were carried on after every 30 days upto 6 months. It was found that with calcium nitrate there was actually a fixation of atmospheric nitrogen both with 2 and 6% as glucose both in phosphated and uuphosphated sets in light as well as dark. The fixation was always much greater in light than in dark. With ammonium nitrate there was a slight fixation when 6% C as glucose was added both in phosphated and unphosphated sets only in slight. With ammonium nitrate no fixation was obtained in dark with 6% C as glucose or with 2% as glucose both in light and dark though there was a marked checking of the loss of nitrogen. With ammonium sulphate only a slight checking of loss was obtained even with 6% C as glucose and phosphate and there was no fixation of atmospheric nitrogen. These results clearly show the superiority of ammonium nitrate and calcium nitrate as fertilisers as compared to ammonium sulphate. Field trials also support this view point.

43. Chemistry of micronutrients applied to soils—Relationship between symmetry additions of Cu and Zn and the b.e c. values of soils, retention of Cu and Zn and their release.

S. G. MISRA AND R. C. TIWARI, *Agricultural ·Chemistry Section, Chemistry Department, Allahabad University, Allahabad.*

Varying symmetries of Cu^{++} and Zn^{++} (in solution) were added to three soils (black, red and alkali soils) which differed in their physico-chemical behaviour and the amounts of copper and zinc retained were ascertained.

The b.e.c. of the soils were also determined after Cu^{++} and Zn^{++} additions. The b.e.c. values were found to be affected, but there was no regular increase or decrease. Other factors like $CaCO_3$, organic matter and pH of the soils were also found to affect copper and zinc retention.

The amount of copper and zinc extracted by neutral normal ammonium acetate was always lesser than the b.e.c. of soils. It clearly shows that even at 4S level of addition of Cu^{++} and Zn^{++} cannot occupy all the exchangeable positions in the soils.

44. Steady flow of a viscous incompressible fluid through an elastic tube with suction at the boundary.

G. TEEKARAO, *Osmania University Hyderabad, (A. P.).*

Steady laminar flow of a viscous incompressible fluid through an elastic tube with porous walls is considered. A normal suction is applied at the boundary. It is shown that as a result of this suction the tube expands in the direction of the flow if the fluid viscosity is sufficiently small. The suction parameter also increases in the same direction from its value at the entry of the tube which is greater than 2.

Both the radial and the axial velocities decrease all along the tube. With a continuous decrease in velocity the Reynolds number also decreases, so that the flow is likely to remain laminar if it is so at the entry. There is an increase in pressure as the fluid moves along and this at some stage cause backward flow at the boundary.

45. Reduction of Quinquevalent Vanadium with Ferrocyanide.

R. K. PRASAD AND K. K. SINGH, *Muzaffarpur.*

The reaction of sodium metavanadate with ferrocyanide has been studied potentiometrically in the range of acid concentrations N/100 to 2N. At acid concentrations greater than N/20, 1·5 moles of ferrocyanide are used up per mole of vanadate, while at acid concentrations less than N/40, 0·5 moles only are necessary. In the range of N/20 to N/40, there is a drastic departure from stoichiometry. The colours of the equilibrium mixtures are hardly suggestive of the reduction to vanadium (III). Assuming the oxidation of ferrocyanide to ferricyanide, it can be said, therefore, that at higher acid concentrations (>N/20) either oxidation to 3·5 stage or some kind of mixed reactions occur, while at lower acid concentrations (<N/40), some polyvanadates might be formed so that the reduction does not proceed far. Further work is in progress.

SECTION OF BIOLOGICAL SCIENCES

ABSTRACT OF PAPERS

1. Fungi causing plant diseases at Jabalpur (Madhya Pradesh)—XII. some Cercosporae—III.

G. P. AGARWAL, *Dept. of Botany, Govt. Science College, Jabalpur.*

The paper includes nine more *Cercospora* occurring at Jabalpur and its suburbs. These include *Cercospora setariae* Atk. on the leaves of some Grass, which is a new fungus record for the country. *Cercospora hyalosopra* on *Corchorus acutangularis* and *Pseudocercospora Vitis* on *Vitis* sp. (wild veriety) are with new host records from Jabalpur. *Cercospora anonae* on *Anona squamosa*, *C. eucalypti* on *Eucalyptus* sp., *C. mangifera-indicae* on *Mangifera indica*, *C. ricinella* on *Ricinus communis*, *C. occidentalis* on *Cassia tora*, and *C. ternateae* on *Clitoria ternatea* are the new record for the state.

2. Additions to the fungi of Jabalpur (Madhya Pradesh)—V.

S. K. HASIJA, *Dept. of Botany, Govt. Science College, Jabalpur.*

In the first four series of the paper 26 fungi occurring at Jabalpur have been described. The present paper includes ten more parasitic fungi. *Hendersonia syzygii* Hasija sp. nov. on the leaves of *Syzygium cumini*, *Phoma ixorae* Hasija sp. nov. on the leaves of *Ixora* sp. and *Phyllosticta agarwalii* Hasija sp. nov. on the leaves of *Dalbergia paniculata* are the new species described. *Colletotrichum truncatum* (Schw) Andrus and Moore on *Alysicarpus bupleurifolius* and *Piricularia zingiberi* on *Hedychium* sp. are the new fungus records for the country. *Grewia hirsuta* for *Phyllosticta sedgwickii*, *Lagerstroemia speciosa* for *Pestalotiopsis versicolor*, *Zingiber officinale* for *Curvularia lunata*, *Musa paradisiaca* for *Deightoniella torulosa* and *Flacourtia ramontchi* for *Alternaria tenuis* are the new hosts record for the fungus described from Jabalpur.

3. Studies on storage rot fungi—I. Carbon requirement.

S. N. BHARGAVA, *Botany Department, University of Allahabad, Allahabad.*

The effect of 28 different carbon sources on the growth and reproduction of three storage rot fungi *viz.*, *Fusarium solani* (Mart.) App. and Wr. (causing dry rot of Gladiolus bulbs), *Botryodiplodia ananassae* (Sacc.) Petrak (causing fruit rot of pineapple) and *Macrophomina phaseoli* (Maubl.) Ashby (causing charcoal rot of potato) was studied.

It was found that amongst the four pentoses included, rhamnose was a good source for the growth of *B. ananassae* and *M. phaseoli*. Arabinose and xylose were good for *B. ananassae* and *M. phaseoli* respectively. Except galactose and sorbose the three other hexoses (glucose, fructose and mannose were satisfactory

sources for the growth of these fungi. The efficiency of disaccharides (sucrose, maltose, cellobiose, trehalose, lactose and melibiose) varied. They were either poor, moderate or good for the growth of these organisms. Amongst the two trisaccharides used in the present study, raffinose was a satisfactory source for all of them, while melezitose was either poor, moderate or good. Starch was a good source for the present fungi while the other polysaccharides *viz.*, dextrin, inulin and glycogen, supported either poor, moderate or good growth. *F. solani* showed good response towards sugar alcohols (glycerol, sorbitol, mannitol and dulcitol) while the behaviour of other two fungi varied. Arbutin the only glyco-side included was a poor, moderate and good source for *F. solani*, *B. ananassae* and *M. phaseoli* respectively. Both the organic acids used (tartaric and malic) were satisfactory sources for the present fungi. Starch supported best growth of *F. solani* and *M. phaseoli* while mannose was best for *B. ananassae*.

The sporulation of all the three organism under study was profoundly influenced by the type of carbon sources. It varied from nil (no sporulation or sclerotial development) to excellent on different compounds.

4. Studies on storage rot fungi—II. Nitrogen Requirement.

S. N. BHARGAVA, *Botany Department, University of Allahabad, Allahabad.*

The effect of 33 different nitrogen (both organic and inorganic) sources on the growth and reproduction of three storage rot fungi viz., *Fusarium solani* (Mart.) App. and Wr., *Botryodiplodia ananassae* (Sacc.) Petrak and *Macrophomina phaseoli* (Maubl.) Ashby causing dry rot of Gladiolus bulbs, fruit rot of pineapple and charcoal rot of potato tubers respectively, was studied under controlled conditions.

It was found that the three fungi could use the nitrates of potassium, sodium, calcium and magnesium, but they behaved differently. *M. phaseoli* had good growth on all of them ; *F. solani* grew satisfactorily on potassium, sodium and calcium nitrates while *B. ananassae* had good growth on potassium nitrate only.

All the ammonium compounds (chloride, sulphate, carbonate and nitrate) were poor sources of nitrogen for *F. solani* and *B. ananassae* while they were good for *M. phaseoli*.

Nitrites of sodium and potassium supported poor growth of *F. solani* but the other two fungi failed to grow on them. Thiourea was very poorly utilized by all the three organisms while hydroxylamine was toxic to *M. phaseoli*. It was, however, poorly utilized by other two fungi. The behaviour of these organisms varied towards urea and acetamide. Peptone was a good source for all of them. In general amino -acids were good sources for the growth of present froms. DL–phenylalanine supported best growth of *F. solani* and *B. ananassae* while L-leucine was best for *M. phaseoli*.

The results showed that the source of nitrogen in the basal medium greatly influenced the reproduction of these fungi. *F. solani* sporulated on all substances except on hydroxylamine and thiourea. The sporulation of *B. ananassae* was restricted to a few sources only. The sclerotial production of *M. phaseoli* was obtained on a number of compounds. In general ammonium compounds suppressed the sporulation or sclerotial development of *B. ananassae* or *M. phaseoli* respectively.

[66]

5. A study of the chondriome in two members of mucoraceae.

B. B. S. RAIZADA AND SHYAMJI LAL SRIVASTAVA, *Botany Department, K. N. Government College, Gyanpur, (Varanasi).*

The chondriome in vegetative and asexual reproductive structures of *Zygorhynchus moelleri* and *Circinella muscae* was studied in living as well as in fixed conditions. Granular mitochondria were seen at the growing tips of young hyphae. In the proximal parts of the hyphae granular, rod shaped and filamentous forms mixed together were observed.

Filamentous form in proximal parts of *Circinella muscae* could not be seen in living condition when stained with 2, 3, 5, Triphenyl tetrazolium chloride.

The chondriome in young sporangium of *Zygorhynchus moelleri* was made up of only the granules. The mitochondria, however, could not be studied in the case of the sporangium of *Cireinella muscae.*

The study of chondriome in the fixed condition revealed that the mito-chondria were seen similar in structure as observed in living condition.

It has been observed that fixative containing acetic acid and absolute alcohol also preserve mitochondria well without altering their structure besides those containing mercuric chloride and potassium dichromate which fix the chondriome excellently.

6. Histophysical mode of action of Insecticides.

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Histological degenerations are caused by the variety of insecticides. Hartzell (1932-46), Woke (1938, 1940), Richards (1941, 1943, 1944, and 1945), Srivastava (1948, 1951), Salkeld (1951), Soliman and Soliman (1948), Chadbourne and Rainwater. (1958) and Sternburg (1960) etc., etc. The water loss due to the insecticidal action is common to a variety of insecticides Wigglesworth (1941), Ingram (1955) and Chattoraj and Sharma (1964). These two identical sections led the present investigator to think that this loss of water might be causing histological degenerations.

In order to find out some histological evidence to support the said idea, untreated cockroaches were run in the dry air for fourteen hours and then the tissues were examined. It was found that the loss of water from the body caused histological changes which are similar to that caused by the insecticides. This suggests that somehow or the other, insecticides by their action might be allowing the withdrawal of water from the tissues and this act of losing the water by the tissues cause histological changes. Lower (1961) carried out such studies with the starved Army Worm larvae and he observed that the midgut epithelium shrinks and retracts irregularly from both cuticle and basement membrane and the proportion of the body fat rapidly diminishes. The effect of starvation in tissues has been eliminated since death occurs in acute cases of poisoning within a short time and yet the pathology develops Sharma and Chattoraj, (1962), and Sharma (1964). The work of Lower (1961) suggests that due to the starvation a vacuum is developed inside the body, cells starts losing turgidity and in turn tissues starts collapsing and pathology develops.

It is well recognized that insects lose water with the change in their morphological and or physiological state (Mellanby, 1935) and this change is also attained with the insecticide treatment Wigglesworth (1941), Ingram (1955) and Chattoraj and Sharma (1964). During the loss of water from the body there is a continuous outflow of water from within of the insests (*i.e.* from all the affected tissues). Naturally this outflow of water is likely to set the internal tissues of insects at a different morphological, physiological and bio-chemical state thereby changing their structural appearance.

Probably due to the action of insecticides there is developed a physical force inside the body which allows the water to withdraw from the tissues. Further this withdrawal of water can be the direct withdrawal of water from the tissues or it can reverse or check the usual process of osmosis and absorption. Consequently this withdrawal of water creates a pressure or pull on the tissues and the cells starts contraction. This shrinkage dislocates and disturbs the cell contents and inturn cause nuclear distortions and cytoplasmic degenerations. This suggests that the speed of water loss has some affect on the pathology and the faster speed of water loss will cause more acute histological degenerations.

However, the above explanation regarding the identical pathology does not rule out the possibility of direct chemical actions and reactions going on inside the body which also disrupts the normal body physiology and behaviour and thereby are also responsible for bringing about pathology and death. The above explanation of histophysical force is one possible way of identical pathology observed with various insecticides.

7. Histological effect of DDT in Red Cotton Bug *Dysdercus koenigi* F.

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Red cotton bugs were topically applied with 57·15 r/gm lethal dose. Histological changes brought by DDT have been observed in all parts of the alimentary canal. Earlier works of Salkeld (1951) and Chadbourne and Rainwater (1953) have reported absence of any pathology with the DDT treatment.

DDT causes no effect on the neurilemma of the Red cotton bugs however, the cortex and neurospongium show acute degenerations. The histological changes are very intense in the thoracic and thoracico-abdominal ganglia than in the brain. Lesions are absent. There is complete degeneration and lysis of the cortical tissue, presence of clear spaces, acute vacuolation, dissolution of cell components, the nuclei appear distorted, vacuolated and chromatin granules show breakdown. In neurospongium there is intense vacuolation, dissolution of fibre tracts, lysis and nuclear degeneration.

Lauger *et al,* (1945) observed vacuole formation and disappearance of cell nuclei in ganglion cell of the DDT poisoned insects. Bodestein (1946) found that DDT could effect the peripheral nervous system. Tobias and Kollrose (1946) concluded that thoracic ganglion are the critical loci for the action of DTT. Roeder and Weiant (1946) pointed out that undoubtedly DDT effects motor nerves and muscle fibres of the cockroach, the tremors characterestic of DDT poisoning being due to the intense bombardment of motor neurones. Roeder thinks that DDT has no significant action on the central nervous system of cockroaches. Welsch and Gordon (1947) observed that DDT acts on peripheral nerve fibrils.

Bozkurt (1948) found no histological changes on the head ganglia and nerves of American Cockroach killed by DDT. Chadbourne and Rainwater (1953) found no histological change in larvae of *Heliothis armigera* with DDT treatment. The highly sensitive ultrastructure of insect nerve is not impaired by DDT, and this poison has not produced any histopathological change in *Calliphora, Lucilia, Phormia* (Witt, 1947) or *Periplaneta* (Richards and Cutkomp, 1945). However, relatively slight changes were noted in the brain of contact poisoned *Musca*, consisting of partial lysis of fibres and nuclear degeneration (Hartzell, 1945).

There are conflicting reports on the histological changes induced by DDT and during the course of present investigations it was found that DDT causes pathology throughout the central part of the central nervous system in Red cotton bugs.

8. Pharmacology of Dieldrin in Grasshopper *Poeciloceruspictus* FABR

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Grasshoppers were topically applied with 6·32 r/gm lethal dose. The insecticide has no effect for the first two hours and after that hoppers show hyperactivity. They run atrandom and at times fall down, show rapid to and fro movement of the antennae, masticate rapidly and the tremors set in the first pair of legs. After half an hour of the onset of these symptoms grasshoppers become restless, they hop from here to there, walk fast, fall down and the contraction and extension of the abdomen is very conspicuous. Within 5 to 6 hours of the treatment tremors cover the other two pair of legs but much too less in intensity, and ataxic gait and fast jumping is observed. The hyperactivity of body and its appendages continue for 3 to 4 hours. Now all the pairs of legs show the same intensity of tremors accompanied with tremors and grasshoppers strike with force the hind pair of legs against the ground. Before striking their hind pair of legs against the ground they stretch their legs and rub it along the body and head and then strike it before the head on the ground. This striking of legs against the ground is very fast and conspicuous and lasts for one to two hours. While striking against the ground they fall down several times on their side backs. Now at this stage whole body of the grasshoppers appears to have been divided into two parts. The intersegmental membrane of the second and third abdominal segments show swelling to the point of rupture. The insect loses body balance and lie on one side of their body. The swollen part of the abdomen show continuous contraction and extension. Grasshoppers remain in this condition for the next 2 to 3 hours and later all the pair of legs are stretched out. The tremors continue to appear in slow and fast cycles. The antennae are not moved and the mastication continues. At times hoppers try to drag their body by giving jerks. After 3 to 4 hours of the onset of tremors and convulsions grasshoppers become completely exhausted. After this period the symptoms go on decreasing and death comes within 16 to 20 hours. The dead hoppers are seen lying on one side of their body with swollen abdomen. The hind part of the abdomen appears raised and the head lie straight. The intersegmental membrane of the 2nd and 3rd abdominal segment is completely spread out and the abdomen at this point forms an angle.

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9. Histological effect of Endrin.

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Endrin was topically applied on the pronotum of the female cockroaches *Periplaneta americana* (L.) in lethal dose *i.e.* 24·09 r/gm. The treated insects were left in the experimental cages and permanent preparations were made of the control and moribund insect's tissues for comparative histological observations.

Acute histological degenerations have been observed in crop than in any other part of the alimentary canal. The nuclei of the muscles of crop become con-tracted and vacuoles in longitudinal and circular muscles. The epithelium gets detached from the muscles and lie haphazardly. The epithelial cells show marked reduction in size and small vacuoles lie in large numbers in the epithel-ium. The cytoplasm become granular and at places lie extruded. The nuclei of the epithelium show marked degeneration. Exfoliation of epithelium is very marked and conspicuous. In midgut, vacuoles lie in the muscles. The whole epithelium is occupied with vacuoles and nuclei become distorted. In hindgut, vacuoles appear all over the epithelium and nuclei give distorted appearance.

Neuropathological changes are of the same type in brain, thoracic and abdominal ganglia as have been reported by Sharma (1965) with the treatment of Methoxychlor in cockroaches. However, with the application of Endrin lesions were not observed which were consistent with Methoxychlor treatment and the intensity of pathology varies greatly.

10. Pharmacology of Allethrin in Grasshopper *Poecilocerus pictus* FABR.

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Grasshoppers were topically applied with 9·67 r/gm lethal dose. The treated grasshoppers do not show any symptoms of poisoning for the first 5 to 10 minutes and sit quiety in the cages. But immediately afterwards they rapidly masticate. and rub their mouthparts against the ground or against the first pair of legs Within half an hour of the treatment tremors appear in the first pair of legs and the abdomen is rapidly contracted and extended. Several times head is stretched downwards with the help of first pair of legs, antennae are moved to and fro and tremors appear in the first pair of legs and increase in intensity. For the next two hours hoppers exhibit jumping movements and show extension and contrac-tion of abdomen with up and down movement and walk with ataxic gait and continuous mastication. After 3 to 4 hours of the treatment a general restlessness in the body sets in, hoppers walk forward and backward, few of them jump and fall on their backs, get up through jerks and again move haphazardly. Within this time tremors cover all the pair of legs. Grasshoppers continue to jump and for next two hours these tremors reduce in intensity and the hoppers are seen sitting quietly. Very slight tremors and general body hyperactivity has been observed for this time. Grasshoppers raise their hind part of the body, masticate rapidly, stretch their legs, show other body hyperactivity and for the rest time sit quietly. Hoppers continue such body movements for 6 to 8 hours. After the lapse of this period tremors appear and increase in the first pair of legs and with-in next 1 to 2 hours cover all the pair of legs. Tremors increase in intensity and frequency with the passage of time. Head is moved from here to there,

stretched downwards and at times rubbed and stretched with the first pair of legs. Tremors cover all the pair of legs within next 3 to 4 hours and later also appear in the abdomen. The antennae are moved to and fro and rapid mastication continues. At this stage convulsions appear and gait of the hoppers is badly disturbed, they find difficulty in walking fall on to their backs, get up again through jerks and lastly they usually fall on one side of their body. The whole body is stretched, legs are badly stretched, mouth parts continue rapid mastication, the antennae are moved rapidly to and fro, and the cycle of fast and slow tremors sets in. The hoppers by now are badly exhausted, the whole body is stretched at times and the tremors decrease in intensity with the passage of time. Death comes within 16 to 18 hours of the treatment.

11. Histolgical effect of Aldrin in the Cockroach *Periplaneta americana* (L.)

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Cockroaches were treated topically on the pronotum with the lethal dose *i.e.* 24·26 r/gm for males and 3·36 r/gm for females. The insecticide was dissolved in acetone and applied through a miro-applicator. The cockroaches were left in the experimental cages and the tissue of the moribund insect's were examined for the pathology. Histological changes were also observed in the tissues of the insect's which survived the lethal dose after 48 hours of the treatment.

Acute histological degenerations have been observed in the crop than in any other region of the alimentary canal. Major histological changes of the alimentary canal include—vacuolation in muscles and epithelium, marked shrinkage and exfoliation and disorganization of epithelium in the foregut and hindgut. The cytoplasm becomes disintegrated and the nuclei give distorted and degenerated appearance.

In nervous tissues, at most places in the brain and the ganglia neurilemma has been removed, cortex show acute·degeneration, vacuolation and presence of clear spaces. Neurosecretory cells become shrunk, vacuolated and their cytoplasm appear degenerated. The neurospongium show tigrolysis, intense vacuolation ; acute cellulur degeneration, and degeneration of the cell components and lysis of the tissues. The nuclei also appear degeneratcd, Vacuolated and their chromatin granules clump.

The Malpighian tubules become shrunk and in most cases lumen disappears. The nuclei become shrunk, pycnotic and at places lie extruded.

Fat bodies show various stages of dissolution and nuclear degeneration.

12. Histological effect of Methoxychlor in Cockroach *Periplaneta americana* (L.)

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Female cockroaches were topically treated with 28·08 r/gm of Methoxychlor and the tissues of the moribund insects were examined histologically.

Histological changes have been observed in all parts of the alimentary canal. These histological changes are of the same nature as have been reported by Sharma and Chattoraj (1962) and Sharma (1965). Worse changes occur in foregut than in any other part of the alimentary canal.

Pathological changes have been observed throughout the central nervous system. Thoracic ganglia have been worse effected. The neurilemma has been separated from the cortex. In cortex there appears complete degeneration of the cortical tissue, acute cellular degeneration, presence of clear spaces and the degenerated nuclei are thrown outside the cortex or lie in vacuolated cytoplasm. The neurosecretory cells become shrunk, vacuolated and their cytoplasm become granular. The damage in neurospongium has been observed as : tigrolysis, acute vacuolation, acute cellular degeneration, degeneration of the fibre tracts, degeneration of the nerve tissue, presence of clear spaces and formation of lesions. The natue of the pathological changes remain of the same type in brain, thoracic and abdominal ganglia except the intensity which varies grealty.

13. Pharmacology of Lindane in *Periplaneta americana* (L.)

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

Cockroaches were treated with sub-lethal (6·3 r/gm for females and 1·21 r/gm for males) and lethal doses (18·9 r/gm for females and 2·19 r/gm for males).

Treatment with sub-lethal doses cause a slight body excitement after 10 to 15 minutes of the treatment. Cockroaches clean their antennae, rub the first pair of legs against each other, and show excited to and fro movement of the antennae. Whereas, cockroaches treated with lethal doses exhibit a very vigrous movement of the body appendages within 15 minutes of the treatment. They clean their antennae several times by holdinge them with the first pair of legs and passing them through the mandibles, they rub the first pair of legs against each other, clean the legs with the mouth parts and show masticating movements. At times they are also seen stretching several times their head downwards with the help of first pair of legs. These symptoms are observed only for half an hour to an hour and then the roaches run away from light and seek dark places. After sometime the roaches come out of their hiding places and start repeating the earlier symptoms with increased frequency. These symptoms last for 3 to 4 hours and after this period they run fast on the ground. The abdomen is raised high on the ground on the legs showing telescopic movements and is very frequently rubbed by the hind pair of legs. They run fast, stop and again run fast, and this stage lasts for 4 to 6 hours. The roaches which could stand this dose do not show advanced symptoms of poisoning and start behaving as do the controls behave. The symptoms of poisoning are the same for both the sexes with their lethal doses mentioned above. In the later stages roaches find difficulty in walking and general restlessness sets in the body. Few cockroaches try to fly, but they fall on their backs and get up with difficulty by jerking movements. Roaches show voilent haphazard movements on the ground and tremors are seen in the legs. At times they are seen moving in circle and at times walk fast and staggering gate is observed. They remained in this condition for 2 to 3 hours. In the later stages, they lose their balance and fell on their backs, and several times get up and drag their body with jerks. Ultimately, roaches fall down on their backs, cannot stand up any more, show extension and contraction of head and up and

down movement of the abdomen. Violent tremors appear first in the legs which later spread all over the body and the abdomen is extended to the point of rupture. Cycles of fast tremors and movements appear and increase in intensity for sometimes which goes on decreasing with the passing time till death comes. Roaches remain in this condition for 4 to 6 hours. Death occurs within 48 hours of the treatment. The dead cockroaches appear moist and the antannae invariably form the figure of a cross.

14. Further studies on the induced haemotological changes in treated insects.

V. P. SHARMA, *Zoology Department, University of Allahabad, Allahabad.*

The insecticides selected for this study were : Aldrin, Allethrin, Endrin, Nuvan, Phosdrin, and Sevin ; and the insects were the adult cockroaches (*Periplaneta americana*), nymphs of grasshoppers (*Poecilocerus pictus*), and the third stage larvae of *Prodenia litura.*

The insecticides were prepared in different concentrations and applied topically to the cockroaches and grasshoppers and by injection to the larvae of *Prodenia litura.* The blood was taken out by amputing the antennae of the cockroaches and grasshoppers and by amputing the prolegs of ths larvae. The blood was heat fixed *in vivo*, a thin smear prepared on the slide, stained with either Wright's stain, Leishman's stain, or haemotoxylin eosin, dehydrated and mounted. The control experiments were also run concurrently with untreated experiment for comparative study.

The action of insecticides in the blood cells of the *Prodenia* larvae cause a general shrinkage of the cytoplasm and pseudopodia like structures come out of the blood cells, there are no vacuoles and most fusiform cells become round. In heamocytes of grasshoppers and cockroaches the conspicuous haemotological changes are observed as : formation of microhaemocytes, magalohaemocytes, abnormal haemocytes and the presence of abnormally large granules.

The nuclei of the blood cells of *Prodenia* larvae are not much damaged excepting that they are dislocated, overlapped by cytoplasmic folds, deeply stained and hypertrophied. But in the blood cells of grasshoppers and cockroaches nuclear degenerations are observed as : raggedness, rupture, atrophy, hypertrophy pycnosis, vacuolation, dislocation, swelling and extrusion.

The insecticides cause : decrease in the visibility of normal structures of cytoplasm, agglutination of blood cells and the decrease in flow in amputed insects.

The intensity and the type of pathology varies as much with the insect as with the insecticide and their doses.

Little haemotological changes were observed after the administration of Aldrin and Nuvan ; marked changes were observed with the application of Phosdrin and Endrin and still intense haemotological changes were observed after the administration of Sevin and Allethrin.

Intense shrinkage and presence of pseudopodia like structures in the blood cells of *Prodenia* larvae is probably due to the direct contact of insecticides and the apparent water loss from the body of the treated larvae.

15. Production of cellulolytic enzymes by gram wilt causing Pathogen.

S. C. GUPTA AND R. K. KOHLI, *Gyanpur.*

Fusarium orthoceras App. and Wr. var. *ciceri* Padwick, an important pathogen causing vascular wilt disease of gram (*Cicer arietinum*) in India, was studied for the secretion of cellulolytic enzymes.

Decoction media of 20% gram seeds or gram seedlings were not found to be suitable for the enzyme secretion. A synthetic medium containing 1·0% glucose, 1·0% carboxymethyl cellulose (CMC), 0·389% ammonium oxalate, 0·1% potassium dihydrogen phosphate and 0·05% magnesium sulphate was found to be better than Czapek's medium with CMC. The fungus was also found to be adaptive for cellulose or its derivative in the medium for the secretion of active cellulolytic enzymes.

Maximum activity of the secreted Cx enzyme and the growth of the fungus were recorded in 4 days old cultures. Ammonium phosphate was found to be best nitrogen source for the enzyme secretion.

The pathogen was also found to secrete Cl enzyme.

16. Contribution to the embryology of Euphorbia peltata Roxb.

P. K. MUKHERJEE, *Nagpur.*

The present paper deals with the study of microsporogenesis, male gametophyte, magasporogenesis, female gametophyte and all the phases of post-fertilization stages.

The archesporium is multicellular and hypodermal. The anther wall consists of epidermis, fibrous endothecium, degenerating middle layer and tapetum of secretory type. Cytokinesis is by furrowing. Pollen grains are arranged tetrahedrally or in isobilateral manner. The pollen grains are 3–celled at anthesis and tricolpate.

The ovary is tricarpellary, trilocular and syncarpous. Ovules are bitegminal crassinucellar and anatropous. Nucellus reaches up to the endostome. The placental obuturator consists of loosely, elongated finger-shaped cells.

The female archesporium is multicellular. A linear tetrad of megaspore is formed. The chalazal megaspore of the tetrad develops into an embryo sac of Polygonum type.

Fertilization is porogamous.

The endosperm is free nuclear to start with. It becomes cellular later and persists in the mature seed.

The hypostase is organized and persists in the seed.

The development of embryo has been studied and keys to Chenopodiad variation of the Chenopodiad type.

The seed coats are formed by both the integuments. Their histology and structure of the pericarp are described in the paper.

17. Studies on the effects of carbon and nitrogen on macro-conidial, micro-conidial and chlamydospore production in Fusarium udum Butler.

MAHENDRA PRASAD AND S. K. CHOUDHARY, *Department of Botany, Ranchi University, Ranchi*

In order to study the effect of carbon and nitrogen on the growth and sporulation of *Fusarium udum* Butler, seven carbon-source variants in six different series of nitrogen concentrations were observed. Sucrose served as carbon-source whereas $(NH_4) NO_3$ as source of nitrogen. Altogether forty-two media of different carbon-nitrogen combinations were inoculated and the population density of macro-conidia, micro-conidia and chlamydospore as well as their interrelationships were tabulated. Dry weight of the fungal mat in each case was estimated. The best yield of macro-conidia and micro-conidia were obtained in the medium containing carbon and nitrogen in the proportion of 3·368 : 0·030 gm/L. Dry weight of the fungal mat too was maximum indicating that maximum carbon-nitrogen is absorbed in this combination only. Further increase in nitrogen concentration inhibits the inclusion of nitrogen by the fungal mat.

Chlamydospore production however was erratic and independent of nitrogen concentration showing almost identical values both in its absence as well as in its maximum strength.

An inversely proportional relationship existed between micro conidial and chlamydospore production in the sense that in all such series where micro-conidial production was at its maximum chlamydospore formation was less. In absence of nitrogen with the increase in carbon there was a very rapid increase in chlamydospore production. On the other hand micro-conidial production was inhibited in absence of nitrogen. However the picture was reversed where with the slightest addition of nitrogen the chlamydospore formation was suppressed and micro-conidial population increased.

18. Morphology of the olfactory organs of *Tetradon cucutia.*

C. M. SRIVASTAVA, *Zoology Department, Ranchi University, Ranchi.*

The present paper deals with the morphology and gross anatomy of a brakish water fish *Tetradon cucutia.* The coarse anatomy of the olfactory organs in the Teleostean fishes seems to have received little attention. Our knowledge is confined to the works of Blane (1884), Bateson (1889), Kyle (1899), Burne (1909), Olmsted (1918) and Teichman (1954).

In *Tetradon* the olfactory opening is circular and simple. It is very close to the eye in an area of soft skin. The anterior nostril is circular, the posterior nostril somewhat crescentic. Both are wide open. The integument between the two forms a partial covering and a gap, to the olfactory chamber and between the two openings.

The olfactory chamber is circular and centrally compressed ; its floor is completly covered by a circular and well defined rosette. It is of normal oval type. It consists of about twelve strong laminae with swollen free margins. The olfactory chamber is expanded beneath the lachrymal bone, forming a pear shaped lachrymal nasal sac with the palatine. The lachrymal is strongly compressed by the movements of the pre-maxilla when the mouth is closed.

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19. Morphology of the olfactory organs of *Tricanthus brevirostris*.

C. M. SRIVASTAVA, *Zoology Department, Ranchi University, Ranchi.*

The paper deals with the gross anatomy of a brackish water fish *Tricanthus brevirostris*. The fish has a laterally compressed and angular body. In this fish the anterior and posterior naris lie very close to each other near the eye. Both the openings are circular in shape. The anterior nostril is naked while the posterior nostril is covered by a flap of skin. The two openings are separated by a thin bridge of skin.

The olfactory chamber is a shallow flattened cavity. It is circular in shape corresponding to the shape of the rosette which precisely fits into the cavity. The cavity is bounded by the lachrymal, nasal and frontal bones. The resette is circular in shape and consists of 24-28 lamina arranged along the sides and around the posterior end of a central raphae. The laminae are leaf-like, narrow at their inside end, broader and flattened at the outer end, and having a free border.

20. Morphological variations in brain of some teleosts.

S. MD. SHAFI, *Lecturer, Department of Zoology, Ranchi University, Ranchi.*

The paper gives a comprehensive study of variations in different parts of brain of *Cirrhina mrigala, Glossogobius giuris, Anabas testudineus, Mystus seenghala* and *Rhynchyobdella aculeata*. Main points of study are :

The comparision of relative size of whole brain to standard length shows that *R. aculeata* and *G. giuris* have respectively smaller and *C. mrigala* and *A. testudineus* have respectively larger size of brain. The olfactory lobes of *R. aculeata, M. seenghala* and *A. testudineus* are prominent as large lobes infront of prosencephalon. But these lobes are scarcely visible as distinct from Prosencephalon in *C. mrigala* and *G. giuris*. Diencephalon has small Pineal body attached through a short stalk on dorsal surface. No trace of Parietal organ has been observed. Infundibulum and Pituitory body are visible only under lens. The crossing of optic nerve fibres is much anterior in *M. seenghala, G. giuris* and *R. aculeata*.

Midbrain shows variations in size and shape of Optic lobes. *A. testudineus* has largest size of it, each lobe being $\frac{1}{4}$ in size to whole brain and *R. aculeata* has the smallest. In general, clean water living fishes show larger size of optic lobes.

C. mrigala, M. seenghala and *A. testudineus* have more prominent Corpus Cerebelli than others. As *G. giuris* and *R. aculeata* are very sluggish in swimming activity, they show much smaller Corpus Cerebelli, Cerebellum of *M. seenghala* is somewhat rectangular in shape and extended upto posterior part of Prosencephalon. Auriculi Cerrebelli are distinct lateral processes in this fish and in *A. testudineus*. *M. seenghala* and *C. mrigala* show Vagus lobes on sides. *Medulla oblongata* in *C. mrigala* and *A. testudineus* tapers more suddenly.

21. Fish Catching Devices in Chhotanagpur.

S. Md. Shafi, *Lecturer, Department of Zoology, Ranchi University, Ranchi.*

The paper presents a detailed study of the various Fish Catching Devices in Chhotanagpur. The construction and methods of operation of the following devices have been described separately.

> (1) Common Cast Net, , (2) Drag Net *e.g.* Doghar Jal, Vertical Net and Kapra Jal. (3) Fixed Net *e.g.* Surface—Floating Gill Net and Bottom-Set Gill Net. (4) Traps. *e g.* Tappa, Jhanjh, Kumni, Otill, Tongue Net, Benki and Bush Trap, (5) Dip Net *e.g.* Lift Net, Chingra Jal, Triangular Net and, (6) Screens.

An account of the types of catches for every catching device and their distribution have been mentioned in a separate table. It has been observed that cast nets and the bamboo stake traps are the most common, being responsible for about eighty per cent of total catch of fishes. As beds of rivers, ponds and tanks are generally rocky, spears like 'Konch' and 'Harpoon' are rarely used for fishing. Another remarkable observation is the introduction of Surface Floating Gill Net and Bottom Set-Gill Net. These two devices have been imported from Thailand. The Surface Floating Gill Net has proved to be more popular in D. V. C. reservoirs of Dhanbad and Hazaribagh districts. This net is made up of nylon thread with mesh of 5 cm to 10 cm size. The net is used in combination of several units of net, each of about 20×100 ft. size. The floats made up of light wood *e.g.* Bombax. Malabaricum, are attached to head lines between gap of units of net. Small weights of burnt clay or of small lead rods are attached to the ground line to keep the nets suspended just below the surface of water.

Among bamboo stake traps, some new kinds of traps made up of split bamboo have been found to be of common use among tribal people *e.g.* Otill. Kumni, Benki and Tongue Net.

22. Determination of optimum pH for the activity of the carbohydrases of the liver of *Amphipnous cuchia* (HAM.).

V. P. Agrawal and Meena Gupta, *D. A. V. College, Muzaffarnagar.*

In the fresh and brackish waters of India and Burma occurs an unusually elongated eel-like, finless amphibious fish—the *Amphipnous cuchia*, living mostly out of water wriggling along the banks in which it burrow in dry season and visiting the water in search of food *i.e.* worms crustaceans, molluscs and fishes. The fish ranging in size from 6″ to 2' has an almost straight uncoiled alimentary canal. The liver is a solid elongated mass, light brown in colour and has several deep transverse furrows on its internal surface.

In this present work the optimum pH for the activity of the hepatic amylase and invertase has been determined, as the liver is the main enzyme secreting gland.

The liver extract was prepared in glycerine. After centrifuging and filtering, it was kept for 72 hours before performing the experiments.

The amount of sugar hydrolysed was calculated by mixing the test solution in standardised Fehling's solution and then titrating it against standard glucose solutions. The difference between the glucose solution used here and the glucose solution used against Fehling's solution only was calculated as the amount of sugar hydrolised by the enzyme.

The optimum pH for the activity of amylase and invertase was studied by incubating 1 ml. of 5% substate solutions, starch or sucrose with 1 ml. of liver extract in which was added 1 ml. of buffer solutions of desired pH for exactly 24 hours, when the mixtures were boiled to stop further reaction and it was found that the optimum activity of amylase and sucrose lies at pH 5·5 and 5·6 respectively.

23. The influence of substrate and enzyme concentration on the activity of Hepatic invertase of *Amphipnous cuchia*.

V. P. AGRAWAL AND MEENA GUPTA, *D. A. V. College, Muzaffarnagar.*

The fish *Amphipnous cuchia* with unusually elongated body exhibits an extreme form of modifications for its amphibious habit and burrowing nature. The fish is found wriggling along the banks of fresh and brackish waters of India and Burma. It is an omnivorous fish feeding mainly on worms, crustaceans, small molluscs and fishes. The alimentary cannal is a straight uncoiled tube. The liver is a single lobed elongated structure having several deep transverse furrows on its ventral side.

In the present work the hydrolysis of sucrose at the different concentrations of the hepatic enzyme and the substrate was determined and it was found that the change in substrate concentration greatly alters ·the activity of the enzymes and the influence is greater at the higher concentration than at the lower. The rate of reaction is also influenced with the change in the enzyme concentrations and the velocity of reaction is directly proportional to the enzyme concentration.

24. Morphology and physiology of the digestive system of *Passer domiticus* (Linnaeus).

V. P. AGRAWAL AND R. K. MITTAL, *D. A. V. College, Muzaffarnagar.*

The bird, house sparrow or *Passer domesticus* is found to feed commonly on the small insects. Its gizzard has also been found full of some grains, a few stones and particles.

The alimentary canal of the bird is long and much coiled. The mouth is guarded with upper and lower jaws which are modified into beak. The buccal cavity is without any teeth. The oesophagus is divisible into three parts, the upper oesophagus, crop and lower oesophagus. The oesophagus opens into the proventriculus which in its turn leads into thickly muscular gizzard. The gizzard leads into long and coiled intestine ; its anterior part is bent in a 'U' tube and forms the duodenum, while the posterior most part forms the rectum which is provided with a pair of rectal caeca. The digestive glands include the liver with gall bladder and the pancreas.

It was found that the pH in the different parts of the gut varies considerably. It ranges from 4·5 to 5·5 in the oesophagus, gizzard, proventriculus, intestine and rectum while it is 5·8 in the pancreas, 6·8 in the rectal caecum and 7·8 in the liver.

It is found that the oesophagus, intestine and pancreas secrete most of the carbohydrases such as invertase, raffinase, inulinase, glycogenase, lactase and maltase. The pancreatic cells also secrete proteases, renin and lipase in addition to many of the carbohydrases.

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25. The heart of *Clarias batrachas* (LINN).

V. P. AGRAWAL AND R. SWARUP, *D. A. V. College, Muzaffarnagar.*

It has been found that the heart of the fish show considerable adaptations in response to the mode of life and the shape of the fish.

The heart of *Clarias* is situated in front of the pectoral region and consists of the sinus venosus, auricle, ventricle and the bulbus arteriosus. The heart of *Clarias* shows some interesting features not found in other fishes:

The cavity of the sinus venosus has a pair of adventitious pouches which increase the internal capacity of sinus venosus.

The auricle is laterally compressed and lies on the right side, embracing the postero-lateral side of the ventricle. The auriculo-ventricular aperture is placed at an angle.

The tubular bulbus arteriosus is a prominent structure measuring about one third the total length of the heart. Unlike other fishes, the bulbus is non-muscular and possesses large internal trabeulae. The bulbus aorta leads into ventral aorta which supplies blood to the different gills and the accessory respiratory organs.

26. A Study on the physiology of in *Mugil corsula* (HAM).

V. P. AGRAWAL AND VIBHANSHU BALA, *D. A. V. College, Muzaffarnagar.*

Mugil corsula is a fresh water fish, commonly available in rivers of Muzaffarnagar district. It is herbivorous in feeding habit.

The alimentary canal of *Mugil corsula* is very long and lies much coiled within the body cavity. It includes the subterminal mouth which leads into the spacious buccal cavity. The oesophagus is very small and passes into stomach which divisible into anterior cardiac and posterior pyloric portion. The intestine is very long and leads into small rectum. The liver is a bilobed gland with a distinct gall bladder. The pancreas lies diffused within and around the liver.

The physiological studies reveal that the pH in the different parts of the gut is very similar to each other and is nearer neutrality being only weakly acid.

The experiments on the qualitative estimation of enzymes show that most of the carbohydrases such as amylase, sucrase, glycogenase, maltase, and raffinase are present in the extract of liver and act within the intestine. Other enzymes like renin, proteases and lipase are also secreted by the cells of the liver and intestine.

27. New recods of Species for "Flora of Allahabad".

T. RAJAGOPAL, *Botanical Survey of India, Central Circle, Allahabad.*

With a view to prepare an "Illustrated Manual" on the Flora of Allahabad as a hand-book for reference by the students of botany of this University town, a scheme for collection and study of the plants of Allahabad, both indigenous

and exotic has been initiated in August, 1962. A thorough study of about 700 field numbers of plants collected so far establishes 18 species (excluding the family Gramineae) as new records of species for this area, considering the works of Srivastava (1938 ; 1949) ; Panigrahi and Arora (1962) and Arora *et al* (1964) as the basis of comparison. This paper presents salient points of their habit, notes on habitat, phenology and locality of occurrence, together with illustrated diagrams of the habit and of dissections of floral parts. Short comments on the distinguishing characters of the species with their allied earlier recorded ones, have also been given for facilitating identification. The following are the new records of species and wherever the collectors names is not given, it is collected by the author.

Argemone ochroleuca Sweet (Sangam, 4166/2) ; *Capparis spinosa* Linn. var. *vulgaris* Hook. f. (Behind Polytechnic College, *Singh* 588) ; *Abutilon hirtum* G. Den (Salori, 6134 ; *Singh*, 955) ; *Cassia surattensis* Burm. f. (Chatham Lines, *Arora*, 4734 ; *Prasad*, 394) ; *Grangea maderaspatana* Poir. (Salori, *Singh*, 517) ; *Senchus eleraceous* Linn. (Mintopark, 2290) ; *Leptadenia reticulata* (Retz.) W. & A. (Police Lines, 3131) ; *Dregea volubilis* (Linn. f.) Benth ex Hook. f. (Police Lines, 3130 ; Mac Pharson Lake, 3130/F ; Chatham Lines, *Prasad*, 3263) ; *Ceropegia bulbosa* Roxb. (Behind Polytechnic College, 3200 and 3200/2) ; *Coldonia procumbens* Linn. (Sangam, 4174) ; *Adhatoda vasica* Nees. (Chatham Lines, *Hanfi*, 726 ; *Prasad*, 1386) ; *Ruellia tuborosa* Linn. (Alferd Park, 3119 ; Chatham Lines, *Arora*, 3898) ; *Mazus japonicus* (Thunb.) Ktze. (Allenganj, 6186) ; *Euphorbia geniculata* Orteg. (Chatham Lines, *Arora*, 3809 ; *Misra*, 5356) *Jatrapha cureas* Linn. (Mooratgunj, *Hanfi*, 1843) ; *Commelina hasskarlii* (Chatham Lines, 2292 ; Malaka, *Singh*, 937) ; *Cyperus aristatus* Rottb. (Chatham Lines, *Panigrahi*, 3880).

Of the species listed as new records for Allahabad by Panigrahi and Arora (1962) and Arora *et al* (1964) the following 9 species are considered as effective ones with reference to Srivastava's Flora (1938, 1949).

Oxalis latifolia HB. and K. (Chatham Lines, *Arora* 4404 ; Khusrobagh, 2291) ; *Alysicarpus vaginalis* DC. (Chatham Lines, *Arora*, 4729) ; *Teramnus labialis* Spreng. (Chatham Lines, *Arora*, 4782 ; Alferd Park, *Singh*, 911) ; *Glinus oppositifolia* (Linn.) A. DC. (Naini, *Singh*, 546) ; *Orthosiphon pallidus* Reyle (Chatham Lines, *Arora*, 3815 ; Manauri, *Singh*, 551) ; *Murdannia nudiflora* (Linn.) Brenan. (C. C. Garden, *Arora*, 3896, and 4712 ; Mac Pharson Lake, 3181) ; *Zygomenes axillaris* (Linn.) Salsib. (C. C. Garden, *Arora*, 3812 ; Mac Pherson Lake, 3194) ; *Cyperus compressus* Linn. (C. C. Garden, *Panigrahi*, 3867) and 4741) ; *Cyperus ·iria* Linn. (Chatham Lines, *Panigrahi*, 3829 ; *Singh*, 908).

28. Contribution to the Botany of Madhya Pradesh—II. (The families Rosaceae to Rubiaceae)

G. Panigrahi and C. M. Arora, *Botanical Survey of India, Allahabad.*

This is the 2nd part of a series of communications on the flowering plants of Madhya Pradesh and presents on enumeration of 74 species belonging to the families Rosaceae to Rubiaceae following Bentham and Hooker's (1883). Notes on habit, habitat, colour of flower and of fruits, exact localities of occurrence together with the names of the collector(s) and the field nos. of the plants flowering and fruiting season, are appended to every species enumerated,

9. Contribution to the Botany of Madhya Pradesh—III. (The families *Ebenaceae* **to** *Convolvulaceae***).**

G. PANIGRAHI AND D. M. VERMA, *Botanical Survey of India, Allahabad.*

This is the third part of a series of communications on the flowering plants from Madhya Pradesh and presents an enumeration of 70 species belonging to the families *Ebenaceae* to *Convolvulaceae* following Bentham and Hooker's (1883) System. Notes on habit, habitat, colour of flower and fruit, abundance in the area, exact localities of occurrence, collector's name and field nos. and lastly, fruiting season, are appended to every species.

30. A new genus (*Dozenkostrema***) for** *Paryphotomum* **Sp. Dozenko, 1956.**

ONKARNATHA, *K. N. Government College, Gyanpur (Varanasi).*

A new genus, *Dozenkotrema* has been created for the trematode described from a hen by Dozenko (1956) who, having not been able to trace collar spines, assigned it to the genus *Paryphostomum* Dietz, 1909 without determining the species. Among other characters, the V-shaped disposition of its Vitelleria, the post equatorial and medium position of its ovary, a large uterus with numerous ova, and a cirrus pouch, lying clearly in front of the acetabulum are some of the important features, which separate the new genus from *Paryphostomum* Dietz, 1909. The generic diagnosis of the new genus is given and *Dozenkotrema aspina* n.g., n.sp. is mentioned as the genotype.

31. What is *Echinostoma australe* **Johnston, 1928 ?**

ONKARNATHA, *K. N. Government College, Gyanpur (Varanasi).*

Echinostoma australe Johnston, 1928 has been included in the genus *Nephrostomum* Dietz, 1909 by Mendheim (1943). While Skrjabin (1956) upholds this taxonomic action, Yamaguti (1958) refers to this form by its original name. In the opinion of the present author *E. australe* does not belong to the genus *Nephrostomum* on the basis of the following characters :

(1) Shape of its head collar.

(2) Much smaller number of collar spines.

(3) Relatively longer oesophagus.

(+) Less unequal suckers.

(5) A different ratio of body breadth and collar breadth.

(6) Smooth testis, and

(7) A narrower strip separating the posttesticular vitelleria.

As such agreement is expressed in restoring the Australian species to the genus *Echinostoma* Rudolphi, 1807 for the present.

32. On the food and feeding habits of four species of Collembola.

S. B. Singh, *Department of Zoology, L. S. College, Bihar University, Muzaffarpur.*

Food and feeding habits of four species of Collembola *i.e. Tomocerus lengicornis* (Muller), *Onychiurus armatus* (Tullberg) *Friesea mirabilis* (Tullberg) and *Neanura muscorum* (Templeton). *T. longicornis* and *O. armatus* are larger, possess mandibles with well developed molar plate and fee on moist solid food particles. *F. mirabilis* and *N. muscorum* are without molar plates. *F. mirabilis* feeds on decayed tissues of animal origins into form of thick fluid. *N. muscorum* feeds on fine particles suspended in fluid.

Gut contents were examined by squash preparations, sections of gut and use of cultures to determine the micro-organisms present ·in the gut. These examina-tions showed that—(1) Guts of *T. longicornis* and *O. armatus* contain fungi like Hyphomycetes, mainly Cladosporium, Alternaria, Pencillium and traces of micor-rhiza ; remains of foliage, stem and root of higher plants ; humus, dead animal tissues and exuviae of their own type, ciliates and encysted amoebae were also recorded. The gut was also full of discarded epithelial cells and Gram positive and Gram negative bacteria.

In *N. muscorum* on the other hand were noted unrecognizable fine debris, yeast, very small hyaline spores and hyphae ; plant tissues, in the form of cellulose materials, amorphous organic matter and occasionally cilates and encysted amo-ebae. The gut of *F. mirabilis* contains macerated animal tissues and in summer months, a large number of Collembolan eggs indicating that the animal had eaten dead female Collembola—a necrophagous habit. Occasionally very small hyaline spores and hyphae, Gram negative and Gram positive bacteria and protozoans were found.

Experiments on culture proved that viable fungal spores and bacteria can pass through the gut of all the four species and cultures could be raised of several fungi and bacteria from faecal derivatives. Food preference specially in respect to the substances discovered in the guts of the respective Collembolans and substances occurring in their natural habitat, was studied. It was concluded that *T. laongicoris* is not a very selective feeder. It fed actively on all the fungi which were observed from the gut nit it showed preference for brown fungi of the family Dematiaceae. *O. armatus* also fed on all the fungi occurring from the gut but has a slight preference for Penicillium. *N. muscorum* preferred fungi (spores of Penicill ium and Aspergillus) to bacteria. Preference from fungi shifts to humus and then to soft decayed wood if these were offered as alternatives. Feeding experi-ments with *F. mirabilis* did not give reliable results.

33. The Structure and Development of the Malpighian tubules in the beetle *Galerucella birmanica* Jacoby.

U. S. Srivastava and M. K. Khare, *University of Allahabad, Allahabad.*

The adult *Galerucella birmanica* has six Malpighian tubules of which two arise from a common point at the postetior end of the mid-gut and four arise a little posteriorly through a common vesicle from the anterior end of the ileum on each side. Two tubules of the posterior set and one of the anterior set join each other, close to the hind-gut and enter the cryptonephric envelope inside which all the

three tubules of both sides separate again and run over the rectal wall in a zig-zag course up to the posterior end of the rectum. The cryptonephric envelope is composed of a thin membrane made of a single layer of greatly stretched cells. The Malpighian tubules have a similar structure throughout with 4-5 cells in a cross-section and a brush border, but the vesicle has a chitinous intima and a muscle layer externally.

The larva has more or less a similar structure and arrangement of the Malpighian tubules.

Only two brief descriptions of the development of Malpighian tubules in Coleoptera exist, viz., Murray and Tiegs (1938) and Paterson (1936). In *Galerucella*, after the formation of the germ band, the stomodaeal and proctodaeal invaginations arise close to its anterior and posterior ends. From the anterior ventral end of the proctodaeal invagination, four small, blind outgrowths arise simultaniously. So far the proctodaeal membrane is not differentiated, but shortly afterwards, it can be observed as a single layer of flat cells. The mid-gut has not been formed yet but the ventral wall of the mid-gut is being laid down. At this stage, the other two Malpighian tubules also arise from the junction of the proctodaeal membrane and the dorsal wall of the proctodaeum. Thus the rudiments of all the six tubules have arisen from the proctodaeum before the mid-gut formation has taken place and have no relation with the latter. While the mid-gut development is being completed, the Malpighian tubules elongate and the two anterior lateral tubules shift a little forward to the posterior end of the mid-gut as reported for the mid-gut appendices in *Carausius* (Savage, 1962).

The region from where the four ventral tubules arise is differentiated into a common stem which later dilates to form the vesicle.

The distal ends of the growing Malpighian tubules, meanwhile, spread over the posterior end of the proctodaeum which would eventually develop into the colon. Simultaneously, from the posterior end of the future colon, the proctodaeal wall gives out a shelf-like fold all round. From the edges of this fold cells are poliferated which extend over and close upon the gut to form a closed, single-layered covering which joins the peritoneal layer anteriorly. As the envelope is developing, future muscle cells invade it and spread over the colonic epithelium.

No support has been found for Henson's views and the entire proctodaeum, together with the Malpighian tubules arising from it, is regarded to be ectodermal in origin.

The newly hatched larva has the typical arrangement of the Malpighian tubules, but it is devoid of brush border. Some time after hatching, the cell border becomes frilled and then breaks to form the brush border. The tubules grow successively in the three larval instars, the maximum size being reached some time before the next moult. In the prepupa, cells become much enlarged and meanwhile small nuclei of imaginal cells are observed at their bases. In the pupa, the enlarged cells become strongly vacuolated and then shrink, the nuclei become deformed and the border becomes indistinct and finally these cells are thrown out into the lumen. In the late pupa, larval cells disappear and imaginal cells take their place and develop the brush border afresh.

34. Structure and Development of Malpighian tubules in the larva of the silk moth Philosamia ricini Hutt.

U. S. Srivastava and M. K. Khare, *Zoology Department, Allahabad University.*

Morphology

In the larva of *Philosamia ricini*, the hind-gut is differentiated into the anterior intestine and the posterior intestine or rectum. There are six Malpighian tubules divided into two sets of three each. Two tubules of each set unite with each other and then the third tubule joins with the common duct formed by the union of the other tubules and thus a common stem is formed which opens into the anterior intestine immediately behind its junction with the mid-gut. The common stem is itself differentiated into a proximal permanent vesicle and a distal dilatable part. The free ends of the tubules are reassociated with the rectum and are enclosed in a cryptonephric envelope.

Development

After the formation of the germ band, the two mesendoderm rudiments appear at its inner surface, close to its anterior and posterior ends. As the stomodaeal and proctodaeal invaginations arise, the mesendoderm rudiments are also pushed inwards. The Malpighian tubules arise at this stage as a pair of ventrolateral outgrowths from the blind end of the proctodaeum at the mediodorsal end of which a mesendoderm rudiment can still be clearly observed. Hence no relationship can be found between the Malpighian bud and the posterior mesendoderm rudiment. Each Malpighian bud soon divides into two branches of which one again divides into two. Thus three Malpighian tubule rudiments are formed on each side and each of these grows posteriorly and is eventually applied to the wall of the proctodaeum.

Later, part of each common stem differentiates into a vesicle. About the same time, from the anterior and posterior ends of the posterior region of the proctodaeum, the proctodaeal wall gives out two circular shelf-like outgrowths which grow posteriorly and anteriorly all round it, finally to meet each other and thus form a double layered cryptonephric envelope which covers the proctodaeum and the Malpighian tubules completely. The cells of these outgrowths do not show division ; instead they appear to stretch out and so become very flat and thin. Meanwhile, muscle cells derived from the mesoderm also become arranged in a layer around the cryptonephric envelope.

While the Malpighian tubules are being differentiated and the cryptonephric envelope is developing, the cells of the anterior and posterior mesendoderm rudiments at the inner ends of the stomodaeum and proctodaeum give out ribbons of cells which extend towards each other and meet in the middle, enclosing a mass of yolk cells. Thus the mid-gut is formed. At this stage the blind end of the proctodaeum appears as a two layered cellular partition between the cavities of the hind-gut and the mid-gut of which the anterior layer is a remnant of the mesendoderm rudiment and is continuous with the wall of mid-gut while the posterior layer is continuous with the proctodaeal wall. Hence the partition is believed to have a double origin and not to be purely endodermal as claimed earlier by Henson and Savage. Since the Malpighian tubules arise from the posterior layer, they are believed here to be proctodaeal and ectodermal in nature.

35. The development of wings in *Dysdercus koenigii* (Fabr.) (Heteroptera : Pyrrhocoridae).

GYANENDRA NATH, *Department of Zoology, University of Allahabad.*

Histological investigations have been made to trace the development of wing structures and venation. The first indication of the development of wing buds is seen in the first nymphal instar in the form of a small hypodermal thickening dorsolaterally on either side of the meso and metathoracic segments. In the second instar, the rudiments become more pronounced, protrude beyond the surface and histologically consists of several layers of cells. Towards the end of this instar, each rudiment also develops a lacuna, but no trachea has yet entered the rudiment. In the third instar, in each of the fore and hind wings, three lacunae are formed which correspond to the Sc, R and M in the fore wing bud and R, M and Cu in the hind wing bud of the adult. Tracheae now enter the wing buds but still do not run into the lacunae. During the fourth instar, five lacunae develop in the fore wing and these correspond to Sc, R, M, Cu and iv and four lacunae are observed in the hind wing which correspond to R, M, Cu and iv. In the fifth instar, lacunae for the vein 2v in the fore wing and J in the hind wing make their appearance and branches and cross veins are developed.

The development shows that wing lacunae are differentiated progressively in the instars and not simultaneously, and they are not complete with regard to branches and cross connections in the earlier stages. It also shows that although there is much coincidence of tracheal and lacunar pattern, particularly in the last two instars, there is no causal connection between the two ; the lacunae do not cause formation of the tracheal pattern, nor do tracheae induce development of the lacunae. But in the later stages, tracheae run inside the lacunae along the course of least resistance.

Histological changes are marked not only from one stadium to the other but also in the different stages of the same stadium and similar is the case with the size of the wing bud. Growth and development are particularly rapid in the last two instars. The differentiation of the two regions of the hemielytra and the pteralia takes place in the last instar.

The work has been compared with the account of Holdsworth (1940, 1942) which is the only other account of exopterygote wing development.

36. On the wing venation of *Dysdercus koenigii* (Fabr.) (Heteroptera : Pyrrhocoridae).

GYANENDRA NATH, *Department of Zoology, Allahabad University.*

The wing venation of adult *D. koenigii* has been described and interpretted in the light of its ontogenic development. The venation of the hemelytra, in particular, can be understood by comparison with the venation in the late nymphal instars which are not obscured and show morphological resemblance with the condition in the adult.

The veins are derived in two groups : the costo-radial group from which are given off Sc, R and M ; and the cubito-anal group from which are given off Cu, 1st and 2nd vannals and J.

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In the hemielytron, the corium is traversed by six longitudinal veins : Sc, R, M, Cu and 1st and 2nd vannals (1V and 2V). Sc does not extend beyond the corium but its trachea runs into the membrane. The anterior branch of M joins R. M, Cu and IV divide into the membrane. The total number of branches is eleven but the number of branches of any vein may vary and thus the total number of branches in different individuals may differ. Tracheation usually corresponds to venation, but atracheate branches are not uncommon. Cross veins connecting M, Cu, IV and their branches are present but these are usually atracheate.

The hind wing has six veins. The anterior most vein R—M contains the tracheae R and M which run close together but eventually tracheae M separates, bends and finally runs along-side of the trachea Cu in a common vein. In the apical part of the wing R, M and Cu are separate. R and M, and M and Cu are connected by cross veins. There are two vannals (1V and 2V) and a jugal vein, the tracheae of which are derive from the cubitoanal group. There is a tracheal capture in an incomplete cross vein between 1V and 2V. The vannal fold is bifurcate.

37. The integumentary glands of the male Centrococcus insolitus Green and its post-embryonic stages (Hemiptera : Coccoidea).

U. S. SRIVASTAVA, Bihar University, AND P. K. SINHA, Bhagalpur University.

The integument has a typical histological structure with the hypodermal cells arranged in a single layer on the basement membrane and convered by the typical cuticular layer. In the last larval stage and the prepupa, hypodermal cells multiply and become somewhat stratified, specially in the prothorax. In the adult, once again, they become single layered.

In the first larval instar, occurs a single trichogen, associated with a seta, on either side of the anal opening. It increases in size in the second and third instars but disappears later.

There are six types of integumental glands appearing at one stage or the other during the post-embryonic life of the insect : (1) The anal glands appear in the first stage larva and lie, one on either side of the anal opening. Each consists of a group of tall cells with sieve-like openings on the integument surface from which a sticky substance, forming the white, waxy anal tubes is given out. (2) The wax glands appear in the second stage larva and are scattered throughout the integument but are specially abundant on the ventral surface. They are unicellular, uninucleated, flask-shaped glands and produce a white, powdery substance forming a distinct layer all over the body. (3) The setal glands appear in the second stage larva in several longitudinal rows on the dorsal and lateral sides of the body, each underneath a group of closely set spines and having its opening situated between the bases of the spines. Each is composed of a compact, rosette-shaped mass of long conical cells having longitudinal striations and canaliculi. They appear to produce slender, long, waxy filaments which emerge from among the group of larval spines, and remain attached to the latter. (4) The unicellular, uninucleated abdominal glands present from the second stage onwards occur, one on either side, of the sixth abdominal segment near its posterior margin. Their function is not understood. (5) The cocoon forming glands appear towards the close of the third stage larva as irregularly groups of five or six glandular cells. (6) The caudal glands appear in the prepupa as groups of several tall cells on the posterolateral sides of the 7th and 8th abdominal segments. They continue in the subsequent stages and grow in size.

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The first four types are present in the third stage larva, but in the late third stage larva, the first three types start degenerating. In the prepupa, the anal and wax glands are totally wanting, the setal glands degenerate further, the cocoon forming glands are present and the abdominal glands are on the increase. In the pupa, only a few setal and cocoon forming glands are seen, the abdominal glands become larger and caudal glands continue to grow. In the adult only the abdominal and caudal glands are present. Each caudal gland now consists of numerous tubular gland cells with their bases directed anteriorly and the necks posteriorly. They produce a secretion which produces the caudal filament with a fluffy layer of wax.

38. Notes on the nervous system of the male *Centrococcus insolitus* Green and its post-embryonic development. (Hemiptera : Coccoidea).

U. S. SRIVASTAVA, *Bihar University* AND P. K. SINHA, *Bhagalpur University.*

The nervous system of the adult male consists of the brain connected with the large compound thoracic ganglion by a pair of thick and nearly straight circum-oesophageal connectives around the oesophagus. The brain is differentiated into the protocerebrum, deutocerebrum and tritocerebrum. The protocerebrum is very large and consists of the protocerebral lobes and optic lobes ; the deutocerebrum is small and consists of two widely separated swellings on the postero-ventral aspects of the brain and the tritocerebrum is still smaller and its two lobes are also situated apart from each other and behind the deutocerebral lobes. Each cerebral ganglion gives off a pair of antennary and three pairs of ocellar nerves.

The thoracic ganglion is large, elongated and compact and is made of five pairs of fused ganglia from which arise five pairs of nerves supplying the legs and other organs.

Both the brain and the thoracic ganglion show a distinct epineurium around the cortical layer of ganglion cells and the central medullary portion.

In the first instar larva, the brain resembles a thick transverse band across the head ; the optic lobes are poorly developed and have a small, group of bipolar nerves each. The brain increases in size through the larval stages, reaching its maximum in the third (last) stage larva when it shows three distinct lobes—a median and two lateral (optic) lobes. In the prepupa, the brain becomes slightly smaller but differentiated into the protocerebrum, deutocerebrum and tritocerebrum and the protocerebrum shows the protocerebral and optic lobes. The ocellar nerves arise from the optic lobes as and when the ocelli are developed. In the early pupa, the brain increases in dimension and the protocerebral lobes start coalescing. In the late pupa, the adult form is assumed and the brain becomes compact ; the protocerebral lobes enlarge and the optic lobes are pressed laterally and ventrally.

There is no marked change in the circumoesophageal connectives and the thoracic ganglion.

Notes on the dorsal vessel, fat-body and pseudovitellus of the male *Centrococcus insolitus* **Green (Hemiptera : Coccoidea).**

P. K. SINHA, *T. N. B. College, Bhagalpur University.*

In the adult male *Centrococcus insolitus* and its other stages, the dorsal vessel or any other comparable organ has not been observed and blood seems to circu-late through the open space in the body cavity.

The fat-body in the adult consits of irregular, pale yellow masses of large, spherical or subspherical cells with obscure outline scanty cytoplasm, large nuclei and various inclusions and fat droplets. They are feebly developed in the head and thorax than in the abdomen where the cells are also larger. Among the fat cells are also seen leucocytes and large amoeboid oenocytes. In an immediately hatched larva, the fat body is absent but by the end of the first instar larva, it develops considerably and the cells gradually increase in size. In later stages, there is slight decrease in size of cells.

The pseudovitellus is a prominent elongated structure occurring along the mid-ventral line and extending from the metathorax to about the 5th abdominal segment and is composed of a number of spherical giant cells each having a large, rounded central nucleus and a large quantity of cytoplasm differentiated into several round or oval spheres bound together by a firm cell membrane. The entire pseudovitellus mass is further enveloped by a fine membrane. During post embryonic development, it shows no major change except that it increases in size in the larval stages but afterwards slightly decreases.

40. Studies on the life history and biology of *Chrysocoris stollii* Wolff. (Heteroptera : Pentatomidae).

M. P. SINGH, *University Department of Zoology, L. S. College, Muzaffarpur, India.*

Chrysocoris stollii occurs abundantly in the Northern regions of U. P. Bihar and West Bengal. Its most favoured host plant is *Croton sparsiflorus*, though it may occasionally feed on *Clerodendron unfortunatum* and Lichi plant.

The population is highest in the months of July to October and reduced from November to February and again May and June. In March and April, once again, it rises again although not much as in July to October. Observations in nature and in the laboratory show that the optimum for the bug is 68°F to 90°F when it is active. At temperatures above 95°F and below 65°F, the bugs go for concealment foliage or in the grasses at the base of the host plant. Mortality of both adults and nymphs increases in the winter and summer when the temperature goes above or below the optimum range (68°F to 90°F).

Sexual demorphism is distinct. Females have a broader abdomen and possess distinct, externally visible, triangular valvifers.

Copulation seems to be influenced by temperature and humidity. It is frequ-ent in July to October and March to April and rare in November to February and May to June. The eggs are creamy white. The difference in colour of the eggs of this species with others may be related to food plants. Egg-laying is frequent in July to October when the temperature ranges between 68°F to 90°F and humidity between 65% to 100% ; it is less frequent in March and April and

still less in November and February. It stops altogether in December and January and again in June. Breeding was made possible in winter by maintaining an optimum temperature in the cage. Incubation period is shortest from July to October and increases progressively in November, December and January and again starts reducing from February to March and April. It increases again in May and June.

Immediately, after hatching, the first instar nymph possesses four-segmented antennae and two-segmented tarsi. Antennae and tarsi become five-segmented and three-segmented soon after the last moult. There is a progressive increase in the body-size in the successive instars. The scutellum and the wing buds start developing in the second nymphal instar and get larger and more distinct in the successive instars. However, the increase in the width of the head-capsule and length of antennae and legs do not conform either to Dyar's law or to Richard's modification of the same. The life-periods of the different instars appear to vary in the different parts of the year, being shortest in favourable periods and longest in adverse conditions (November to February and May to June).

41. The thoracic glands of _Chrysocoris stollii_ Wolff. (Hetaroptera : Pentatomidae).

U. S. Srivastava and M. P. Singh, _University Department of Zoology, L. S. College, Muzaffarpur, India._

There is a pair of thoracic glands, one on each side of the body. Each thoracic gland consists of eight to ten rows of fairly large nuclei surrounded by a little cytoplasm. The nuclei and the cytoplasm are enclosed by a long protoplasmic sheath, resulting in the formation of string-like structures. These strings lie superficially on the thoracic fat body and are connected, on the one hand, with the prothoracic tracheal trunk and, on the other, with the salivary gland.

In the freshly moulted nymphs, as shown by those of the fourth and fifth instars, the thoracic gland is much reduced and contains smaller nuclei and thin cytoplasm. The nuclei become larger, their nuclear membrane becoming distinct and the cytoplasm becomes granular. In older nymphs, the nuclei have reached the maximum size and the cytoplasm shows small lightly stained vesicles, besides the granules. Sometime before the moult, the nuclei become considerably shrunk, the cytoplasm becomes smooth and free of granules and vesicles, but contains clear spaces or vacuoles.

In the adults, about 12 hours after final moult, the gland is much reduced and signs of its degeneration are obvious. The gland disappears completely after 24 hours of final moult.

In the nymphal period critical period occurs some 48 hours before the moult. Degeneration of the gland in the adult signifies that the gland is needed for bringing about adulthood and is not required once this condition is reached.

42. The Malpighian tubules of _Chrysocoris stollii_ Wolff (Heteroptera : Pentatomidae) and its postembryonic development.

M. P. Singh, _University Department of Zoology, L. S. College, Muzaffarpur, India._

There are two pairs of very long Malpighian tubules in _Chrysocoris stollii_. The two tubules arising from either side of the ileum unite at their distal ends

with each other to form a closed loop. Each tubule is differentiated into a short proximal region, a much longer coiled distal region and a very small transitional region between these two. The proximal region is wider with cells having strongly granular cytoplasm and the lumen-filled with a fluid of thicker concentration. The distal region is narrower, with cells containing less granular cytoplasm but many small vesicles and its lumen is filled with a clear fluid. The transitional region /shares the histological characters of both. It seems in *Chrysocoris* like *Rhodnius* (Wigglesworth, 1939), the absorptive and secretory regions are separate from one another. Throughout the length, the tubule has brush type border as in Dysdercus (Srivastava and Bahadur, 1961).

The ileum is a large thin-walled sac, receiving opening of all the four Malpighian tubules and communicating anteriorly with the posterior end of the mid-gut and posteriorly with the rectum.

In the newly hatched first nymphal instar, there is no differentiation of the brush border or differentiation into the proximal and distal regions. These characteristics appear in the late first nymphal instar, showing that the development of the tubule is not completed by the time hatching occurs, but it continues in the first instar nymph. Once fully differentiated, the tubules show cyclical changes in each instar manifested by increase in the size of the tubules, height of cells and the size of nuclei. In each instar, growth seems to stop altogether sometime before the next moult. Thus development during nymphal period takes place in steps.

43. Histological changes in the mid-gut epithelium of *Chrysocoris stollii* Wolff. (Heteroptera : Pentatomidae) during metamorphosis.

M. P. SINGH, *University Department of Zoology, Bihar University, Muzaffarpur, India.*

The secretory activity of the mid-gut cells is at its peak in the well grown nymphs and it declines somewhat just before moult and remains low till some time after moult. In the nymphs approaching next moult, a number of cells in the first, second and third ventriculi are heavily vacuolated and most of them are on the verge of being detached from the epithelial layer and some of them already have been thrown off into the lumen. At the same time, here and there along the basement membrane are seen some very small cells containing small nuclei and very little cytoplasm. At places such cells are found in small groups, though the number in any group hardly exceeds five or six. In nymphs just after moult, most of the vacuolated cells have been completely detached and the younger cells have become larger and gradually come in line with the other cells of the epithelium. The process of regeneration during metamorphosis observed here seems to be different from that observed in Orthoptera and Isoptera (Weyer, 1936), in Coccinella (Pradhan, 1939), in Lepidoptera (Gray, 1931) and in Diptera (Perez, 1910).

44. Studies on the alimentary canal of *Chrysocoris stollii* **Wolff (Heteroptera: Pentatomidae).**

U. S. SRIVASTAVA AND M. P. SINGH, *University Department of Zoology, Bihar University, Muzaffarpur, India.*

The stomodaeum is divisible into the cibarium, pharynx and oesophagus. The cibarium is a wedge shaped tube with its thin dorsal wall deeply invaginated into the lumen. Along the dorsal invaginated wall, are inserted dilator muscles. The alternate contraction and relaxation of the dilator muscles causes the invagination to be pulled out and produce suction. The pharynx merges posteriorly with the oesophagus just behind the brain. The pharynx and oesophagus are lined with cuboidal cells and a chitinous intima thrown into folds. At the junction of the oesophagus and the midgut is the oesophageal valve which is a richly folded structure, consisting mainly of a long cuticular plug hanging into the lumen of the first ventriculus and a few cells along the anterior part of the valve. The oesophageal valve seems to be a continuation of the chitinous layer of the oesophagus. There is a distinct ring of cells just posterior to the point of origin of the oesophageal valve, which seems to be homologous with the cells secreting the peritrophic membrane.

The midgut consists of the large, sac-like first ventriculus, the tubular second ventriculus, the swollen third ventriculus and the long fourth ventriculus bearing two rows of gastric caeca on either side. The fourth ventriculus opens ventrally into the ileum close to the ileo-rectal opening.

The different parts of the midgut are lined by columnar epithelial cells, majority of which are binucleate. The cells in the first, second and third ventriculi contain cytoplasm with vesicles and vacuoles and may, therefore, be regarded secretory. On the contrary, the cells of the fourth ventriculus appear non-secretory. Cells of the gastric caeca contain fairly large nuclei and their apical parts are vacuolated. These cells pick up vital dye from the haemolymph very quickly and pass it on through the caecal lumen to the fourth ventriculus and appear to help in the elimination of excess of water from the haemolymph. The lumen of the caeca contain large number of bacteria of different shapes and sizes whose function is yet to be ascertained. In between the rectum and the midgut intervenes a thin-walled, sac-like ileum into which open the four Malpighian tubules. The ileo-rectal opening is guarded by a valve opening towards the rectum.

The large sac-like rectum is lined with chitinous intima. The dorsal wall of the rectum forms the rectal pad with large glandular cells which help in reabsorption of water and some soluble substances. Muscles are better developed in the nonglandular, ventral part. Which has smaller cells containing smaller nuclei and nongranular cytoplasm and a wall developed chitinous layer.

45. The structure and function of the mouthparts in the Collembolan— *Tomocerus longicornis* (Muller).

S. B. SINGH, *Department of Zoology, L. S. College, Bihar University, Muzaffarpur.*

The mouthparts of *T. longicornis* are characterised by stout mandibles with well developed molar plates. The basic structure and musculature of these and other components resemble those described by Hoffmann (1905 and 1908) but

there is a considerable difference of opinion regarding the interpretation of their functional relationship. Certain cuticular structures, like the epipharynx and hypopharynx bearing a large number of bristles and the oral valve, which were not described in detail before have been studied and their role in feeding has been assigned. The endoskeleton which was wrongly referred to by earlier authors as the tentorium, has been studied in detail and redescribed. The author's interpretation of mandibular movement agrees broadly with than of Manton (1964). In *T. longicornis* the cutting and grinding is performed largely by rotating movement and not by adduction and abduction movements. The abductor movement is of very small amplitude and restricted owing to lack of space in the pre-oral cavity and presence of various cuticular structures, which inhibits transverse movements.

T. longicornis generally feeds upon solid food particles and there is a correlation between its feeding habits and structure of mouthparts. The structure and arrangement of mouthparts permit *T. longicornis* to feed on fluid food also.

46. The feeding mechanism of *Onychiurus armatus* (Tullberg) Collembola.

S. B. SINGH, *Department of Zoology, L. S. College, Bihar University, Muzaffarpur.*

Onychiurus armatus feeds upon solid food particles of small size as well as on fluid food without loss of hydraulic efficiency and is provided with a feeding mechanism which can help both. It has stout mandibles with well developed molar plates which help in mastication of the food material. The musculature and muscular action resemble those of *T. plumbeus* described by Hoffmann (1905 and 1908) but differs considerably with those described by Denis (1928) and Tuxen (1959). The hypopharynx and epipharynx are provided with a large number of bristles or processes like those of other solid food feeding forms *e.g. T. longicornis*. However, the hypopharynx is produced postero-dorsally to form a tongue like process (the oral valve) lying between the lateral folds of the epipharynx. The epipharynx is itself wedge-shaped anteriorly, and here it divides the food meatus into two lateral food channels. This has not been observed or recorded by earlier workers. The anterior and posterior-tentorial apodemes together with other endoskeletal elements of the head which were wrongly interpreted in earlier works inadequately described, have been thoroughly investigated.

47. Mouthparts and feeding mechanism in *Friesea mirabilis* (Tullberg) Collembola.

S. B. SINGH, *Department of Zoology, L. S. College, Bihar University, Muzaffarpur.*

Friesea mirabilis is minute Collembola (0·5 mm in length) living deep down in the soil. It's mandibles are characterised by the lack of mandibular molar plates. The structure of the chitinous mouthparts, their musculature and mode of action, hither to unknown, have been described in detail. The general plan of the structure and musculature of the mouthparts are similar to those of *T. longicornis* and *O armatus* (forms in which mandibles bear well developed molar

plate). Like *T. longicornis* and *O. armatus* the mandibles employ a rotatory protraction and retraction movement which serves to scrap and scratch the food surfaces. The chitinous mouthparts are relatively weak and delicate and are provided with fewer and thinner muscles. The homology and analogy of these muscles have been described. Since these animals feed on fluid and semi-solid food (*e.g.* dead and partly decayed and liquified) without continution, consequently the feeding mechanism is simpler and need for strong rotational force for mandible is unnecessary and consequently less developed. The main work of the mandible is done while it is being retracted. The anterior tentorial apodeme which supports a number of muscles in *T. longicornis* and *O. armatus* is absent or reduced to minor vestiges in *F. mirabilis*. A transverse maxillary tendon, supporting some of the maxillary muscles in *T. longicornis* is absent in *F. mirabilis*.

48. The mouthparts and feeding mechanism of a fluid feeding Collembolan—*Neanura muscorum* (Templeton) Collembola.

S. B. SINGH, *Department of Zoology, L. S. College, Bihar University, Muzaffarpur.*

Neanura muscorum is a minute Collembolan (about 2·5 mm in length) confined to decaying logs and leaf litter. It feeds on fluid food and is incapable of ingesting any solid food material. It is provided with mandibles which are devoid of mandibular molar plates and maxillae having been modified in the form of stylets. The hypopharynx and epipharynx are devoid of any bristles. The anatomy of other chitinous structures and musculature connected with these has been described in detail. Of special interest are the powerful epipharyngeal dilator muscles which extend over the greater part of the length of the epipharynx. Nevertheless, on the whole the number of muscles connected with the mouthparts is reduced and they have become more slender and incapable of producing significant power. These are associated with the loss of grinding function by the mandible and the simpler type of movement of the maxilla. Until recently all Collembola having mandibles without molar plates were regarded as carnivorous but the findings of the present study do not support this hypothesis in its entirety.

49. Structure and postembryonic development of female reproductive organs of *Chrysocoris stollii* Wolff. (Heteroptera : Pentatomidae).

U. S. SRIVASTAVA, AND M. P. SINGH, *University Department of Zoology, Bihar University, Muzaffarpur, India.*

The internal repropuctive organs of the adult female comprise a pair of ovaries with seven orarioles in each, paired oviducts, common oviduct, tubular accessory glands, spermatheca, paired anterior sacs and an unpaired posterior median sac. The spermatheca is differentiated into the proximal tubular spermathecal duct opening dorsally into the genital atrium much posteriorly, the middle, sac-like reservoir and the distal, knob-like glandular part. The function of the paired anterior sacs and the median unpaired posterior sac is not understood but they are obviously secretory. Such glands have not been previously described in the Heteroptera.

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The external genitalia consist of two pairs of valves and valvifers, one pair of each on the eighth and ninth segments. The valves are membranous except in their apodemal parts. The valves of the first pair are connected with each other anteriorly by the inter-valvular membrane. The valvifers of the first pair are large, triangular plates enclosing the genital atrium from the ventral side. The valvifers of the second pair are connected with each other by the inter-valviferal or inter-gonocoxal membrane. The paratergites of the eighth segment are completely separated from the eighth sternum and are fused with the ventro-lateral margins of the eighth tergum. The paratergites of the ninth segment are large, free plates with the reduced tenth sternum between them.

The ovaries and paired oviducts develop from mesodermal rudiments which appear in the first nymphal instar. The common oviduct arises from a rudiment on the inter-segmental membrane behind the seventh sternum in the third nymphal instar and grows anteriorly, and by the end of the fourth nymphal instar it joins the posterior ampullar ends of the paired oviducts. In the fifth nymphal instar, the common oviduct becomes continuous posteriorly with the genital atrium and from the roof of the latter tubular glands develop.

The anterior paried sacs and the posterior unpaired sac also develop as outgrowths from the roof of the genital atrium in the fifth nymphal instar.

The spermatheca develops in two parts, the middle, sac-like reservoir and the distal, knob-like part are formed in the early fourth nymphal instar by the fusion of invaginations at the base of the first pair of valves and at the base of the second pair of valves, while the spermathecal duct arises in the fifth instar from a longitudinal invagination in the dorsal wall of the genital atrium. The mode of origin of the spermatheca observed here is different from those previously described by George (1928) and Metcalf (1932) in *Philaenus*, Rawat (1939) in *Naucoris* aud Gupta (1951) in *Dysdercus*.

In the late third nymphal instar a median invagination occurs on each of the eighth and ninth sterna, as a result of which the rudiments of the first and second pairs of valves are formed respectively in the form of buds. In the fourth nymphal instar nymph, the parts of the sterna lateral to the rudiments of the valves on both eighth and ninth sterna, differentiate as valvifers. In the last nymphal instar the paratergites of the eighth and ninth sterna are differentiated and come to occupy their characteristic position.

50. Structure and postembryonic development of male reproductive organs of *Chrysocoris stollii* Wolff. (Heteroptera : Pentatomidae.)

U. S. SRIVASTAVA AND M. P. SINGH, *University Department of Zoology, Bihar University, Muzaffarpur, India.*

The internal male reproductive organs of *Chrysocoris stollii* consist of a pair of testes composed of seven follicles each, paired tubular vasa deferentia opening along with a pair of long tubular mesadenia into the central tube of the bulbus ejaculatorius, the long ejaculatory duct and two paired and one unpaired ectadenia. The bulbus ejaculatorius is the anterior dilated end of the ejaculatory duct and consists of an outer investing epithelium, a middle layer and a central layer. The central tube receives the contents of the vasa deferentia and the mesadenia, the space between the central tube and middle layer contains the

secretion of the cells of the middle layer, and the space between the chitinous layer and cells of the outer investing epithelium contains the secration of the ectadenia. The ejaculatory duct posteriorly dilates into a small ejaculatory reservoir in the phallosoma and ultimately opens to the outside on the tip of the vesica.

The external genitalia consist of a median intromittent organ and a pair of claspers. The former comprises a proximal phallobase connected with the ninth sternum by an articulatory apparatus, a middle phallosoma and the distal conjunctiva. The conjunctiva further consists of the outer conjunctival membrane, three pairs of conjunctival appendages and a median central vesica.

The testis, vasa deferentia and their posterior ampullar ends are all mesodermal in origin. The mesadenia are also mesodermal because they arise from the ampullae of the vasa deferentia.

The ejaculatory duct arises from the anterior ventral half of the mesomeres or inner lobes which themselves arise from the splitting of the primary genital lobes formed on the inter-segmental membrane behind the ninth sternum. It grows forward and is differentiated anteriorly into the bulbus ejaculatorius. The ectadenia arise from the bulbus ejaculatorius in the fifth nymphal instar.

The external genitalia arise from a pair of buds (primary genital lobes) grown on the intersegmental membrane behind the ninth segment in the late third instar. These soon divide into a pair of outer buds, the paramere lobes and pair of inner buds, mesomere lobes. The latter unite to form the concentric tubes of hypodermal cells of which the inner one forms the vesica and the outer one fuses laterally with the inner sides of the paramere lobes to form a double layered structure. It is this double layered structure which gives rise to the phallobase, phallosoma, the conjunctival membrane and the conjunctival appendages.

The claspers are developed from the lateral areas of the ninth sternum in the early fifth nymphal instar and arise independently of the intromittent organ. Thus in this regard, the present observations differ from the finding of Christophers and Cragg (1922), Singh Pruthi (1924), Rawat (1939) and Snodgrass (1957) who consider that the claspers also arise from the phallic lobes from which the intromittent organ arises.

51. Fishery management with the help of 0 : 0 Dimethyl-2 : 2-dichlorovinyl phosphate, a new insecticide.

U. S. SRIVASTAVA AND S. K. KONAR, *University Department of Zoology, Bihar University, Muzaffarpur, India.*

One of the major problems of fishery management is the existence of predatory insects and predatory or undesirable fishes in fishery reservoirs. The task of their removal or eradication without damage to the crops being reared is faced with many difficulties.

Experiments have been conducted for their eradication with the help of chemicals and encouraging results have been obtained with a recent insecticide, 0 : 0 Dimethyl-2 : 2-dichlorovinyl phosphate or DDVP (Manufactured and sold as 'Nuvan' by Ciba Ltd., Switzerland) of which the emulsifiable form has been used. Laboratory experiments for the determination of the lethal dose of DDVP for the commonly found insects and fishes have been carried out at room temperature and mortality count made in a maximum of 168 hours in each case.

Insects have been found to be most susceptible to the poison. LD_{100} of the insecticide for *Nepa, Sphaeroderma, Ranatra, Dytiscus, Dytiscus* larva, *Hydrophilus* and dragon-fly nymphs are 0·5, 0·1, 0·2, 0·5, 0·09, 0·5 and 0·2 ppm respectively. Cent per cent mortality is brought about in varying periods in different cases, but the period ranges ordinarily from about 6 hours to 58 hours. Fishes are comparatively more resistant and their lethal doses show a much greater difference from one species to the other, but ranged from 3 to 30 ppm. Among the fishes experimented with, *Labeo rohita* and *Esomus dandrica* proved most resistant. LD_{100} of the insecticide for the different fishes tested are as follows : *Labeo rohita* late fingerling 30 ; *Esomus dandrica* 30 ppm ; *Puntius sophore* 10 ppm ; *Trichogaster fasciatus* young 3 ppm, adult 5 ppm ; *Mystus vittatus* 10 ppm ; *Amphipnous cuchia* 5 ppm ; *Rita rita* 5 ppm ; *Nandus nandus* 5 ppm ; *Channa punctatus* fingerling 3 ppm ; adult 5 ppm ; *Mastocembelus pancalus* 5 ppm ; *Macrognathus aculeatum* 5 ppm. The time required for lethal action ranged in different cases from about 11 hours to 16 hours.

The residual effect of 20 ppm insecticide in water at a temperature of 66°F to 75°F does not last beyond three weeks.

The results indicate that predatory insects can be eradicated from hatching and nursery ponds by treating them with 0·5 ppm DDVP and similarly most of the undesirable fish can be got rid of by treating the ponds with a suitable dilution of this insecticide.

Further work on the various aspects of the problem is in progress.

52. **Effect of mixture of amino acids on the growth and sporulation of certain fungi.**

S. S. PRASAD, *Department of Botany, University of Bihar, Muzaffarpur.*

Effect of different sets of mixtures of four amino acids was observed on the growth and sporulation of three fungi *viz. Pestalotia pauciseta* Sacc., *Botryodiplodia theobromae* Pat. and *Colletotrichum gloeosporioides* Penz., which were isolated from leafspots of *Nephelium litchi* Camb. On the basis of the results of previous experiments, both poor and good sources were selected out of the preparation of the mixtures. The amounts of various amino acids per litre of the mixtures were so adjusted as to provide total amount of nitrogen equivalent to that present in 3·5 g KNO_3,

B. theobromae and *C. gloeosporioides* exhibited selective utilization of the amino acids from the mixtures, while *P. pauciseta* seemed to utilize both good and the poor sources at the same rate. Nevertheless, cystine of the mixture appeared to have a pronounced influence on the overall growth and sporulation of this pathogen. It was also noted that all the organisms showed simultaneous utilization of both good and the poor sources. The rates of assimilation of the different amino acids when supplied individually had no direct relation with their utilization from their combination with other forms. Further, the suitability or unsuitability of an amino acid could not be correlated with its rate of utilizatoin from the mixture.

The results of sporulation also revealed that there could not be any correlation between the mixtures and individual sources (except in case of *P. pauciseta*,

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where the sporulation seemed to be influenced by cystine). Good growth of *P. pauciseta* and *B. theobromae* on the mixtures was associated with only fair and poor sporulations respectively of the pathogens. It was only in the case of *C. gloeosporioides* that good growth of the fungus was also associated with its excellent sporulation on the mixture of the amino acids.

53. pH drift during the growth of certain pathogenic fungi on different carbon and nitrogen sources.

S. S. PRASAD, *Department of Botany, Bihar University, Muzaffarpur.*

Pestalotia pauciseta Sacc., *Botryodiplodia theobromae* Pat. and *Colletotrichum gloeosporioides* Penz., which were isolated by the author from diseased leaves of *Nephelium litchi* Camb., were artificially grown on 21 sources of carbon and 18 sources of nitrogen by replacing the glucose and KNO_3 of the basal medium (Glucose- 10·0 g; KNO_3—3·5 g; KH_2PO_4—1·75 g; $MgSO_4,7H_2O$—0·75 g dissolved in 1 litre of double distilled water) respectively, and the trend of pH changes was observed. The initial pH of the medium was adjusted to 6·0 in each case. The incubation period was of 15 days.

During the growth of the organisms on different carbon sources, it was revealed in general that the hydrogen-ion concentration of the media gradually increased from pH 6·0 to nearly the neutral point *i.e.*, pH 7·0. This increase in pH may be attributed to the absorption of nitrate ion without a corresponding utilization of the potassium ion. A slight initial fall in the pH of glucose medium was noted, which might be owing to the conversion of glucose to gluconic acid.

The pH changes during the incubation of the three pathogens on nitrogen sources depends upon the type of the source. In the case of basic amino acids pH dropped off to about 5·0. This may be due to the accumulation of organic acids resulting from the deamination of the amino acids and differential absorption of the basic group from the media. In certain cases owing to the accumulation of ammonia at later stages, there was a rise in the pH. A lowering of the pH was also noted when the fungi were cultivated on ammonium salts. It might also be attributed to the differential absorption of the basis group from the medium. In case of acidic amino acids there was a rise in the pH of the medium even up to 8·5. This might be due to the differential removal of the acidic group. Similar results were obtained with potassium nitrate, because the nitrate ions were used rapidly than potassium ions.

54. Temparature and pH relations of certain species of *Colletotrichum*,

MISS BANI ACHARYA, *Research Scholar, Department of Botany, Bihar University, Muzaffarpur.*

Effect of temperature and pH on the growth and sporulation of three species of *Colletotrichum* viz. *C. ixorae* Griff. and Maubl., *C. dematium* (Pers. ex Fr.) Grove

and *C.* sp. isolated respectively from the leaf spot of *Ixora parviflora* Vahl., *Jasminum sambac* Ait. and *Magnolia grandiflora* (Moc. and Sesse) ex DC. was studied. The organisms were incubated for 15 days on 25 ml of Asthana and Hawker's medium 'A' contained in 150 ml Erlenmeyer flasks. Each experiment was run in triplicate. The temperature experiments were run at 9 different temperatures varying between 5° and 45° fixed at intervals of 5°C., while the pH experiments were run at 18 different hydrogen-ion concentrations ranging between 1·5 and 10·0 at intervals of 0·5. The pH experiments were conducted at a constant temperature of 25°C. The inferences relating to growth have been drawn from the dry weights of the mycelial mats. Sporulation has been graded on the basis of number of spores seen in the microscopic fields when examined under low power.

None of the pathogens could grow at 5° and 45°C. Growth of all the organisms was quite satisfactory between 15° and 35°C. 25°C. was the optimum temperature for the growth of *C. ixorae* and *C.* sp., while *C. dematium* yielded maximum mycelial crop at 30°C. *C. ixorae* and *C. dematium* could not sporulate at 10°C, but *C.* sp. rendered fair sporulation at this temperature. Excellent spore production by *C. ixorae*, *C. dematium* and *C.* sp. was observed between 20° and 33°C, 20° and 25°C, and 15° and 30° C respectively. Beyond the ranges mentioned, sporulation of the fungi at other temperature was from poor to good.

The organisms did not grow at the low pH of 1·5. *C. dematium* failed to grow at a pH of 2·0 also. Growth of the pathogens was adversely affected at high pH as well. It was very feeble at pH 10·0. *C. ixorae* and *C. dematium* showed maximum growth at pH 6·5, while *C.* sp. yielded best mycelial crop at pH 6·0. *C. ixorae* and *C.* sp. manifested excellent sporulation between pH 3·0 and 8·5, while *C. dematium* sporulated excellently between pH 3·0 and 8·0. Outside the ranges indicated, sporulation of the fungi was from nil to good at different hydrogen-ion concentrations.

55. Effect of Temperature and Hydrogen-ion concentration on the growth and sporulation of certain pathogenic fungi, isolated from the leaf-spots of *Swietenia mahogani* L. and *Swietenia macrophylla* King.

Roy A. B. VERMA, *Department of Botany, Bihar University, Muzaffarpur.*

Three fungi *viz.* *Colletotrichum* sp., *Pestalotia* sp. and *Botryodiplodia* sp. have been isolated from the leaf-spots of *Swietenia mahogani* L. and *Swietenia macrophylla* King. For the identification of species of these fungi, diseased leaves and cultures have been referred to the Mycological Institute at Kew. The fungi were incubated on 25 ml of Asthana and Hawker's medium 'A' contained in 150 ml flasks for 15 days. Each experiment was run in triplicate. The temperature experients were run at 9 different temperatures varying between 5° and 45°C, fixed at intervals of 5°C, while the pH experiments were run at 18 different hydrogen-ion concentrations ranging between 1·5 and 10·0 at intervals of 0·5. The pH experiments were conducted at a constant temperature of 25°C. Dry weight of the fungal mats was taken after the incubation period, which has been used to show the measure of growth. Sporulation gradation has been done on the basis of the number of spores seen in the microscopic fields under the low power of microscope.

None of the three pathogens could grow at 5°C and 45°C. *Colletotrichum* sp. produced satisfactory mycelial crop between 10° and 35°C, while *Botryodiplodia* sp. and *Pestalotia* sp. manifested satisfactory growth between 15° and 35°C. 25°C was found to be the optimum temperature for the growth of all the three fungi. *Colletotrichum* sp., *Botryodiplodia* sp. and *Pestalotia* sp. respectively rendered excellent sporulation between 15°C and 40°C, 20°C and 35°C, and 20°C and 35°C. Outside the aforesaid ranges sporulation was from nil to good.

The fungi under study could not tolerate the low pH of $1\cdot5$ and $2\cdot0$. Growth was unsatisfactory at low and high pH. $6\cdot0$ was found to be the most suitable pH for the growth of *Colletotrichum* sp. and *Pestalotia* sp., while *Botryodiplodia* sp. manifested maximum growth at pH $5\cdot5$. *Colletotrichum* sp., *Botryodiplodia* sp. and *Pestalotia* sp. respectively showed excellent sporulation between pH $2\cdot5$ and $8\cdot5$, $3\cdot5$ and $7\cdot0$ and $3\cdot0$ and $8\cdot0$. Beyond the above ranges sporulation was from nil to good.

56. Effect of diet conditions on the percentage of wigned males in *Laccifer lacca* Kerr (Coccoidea : Hemiptera).

K. C. Bose and G. P. Tulsyan, *University Department of Zoology, Ranchi University, Ranchi.*

The effect of partial starvation on the percentage of winged males is discussed in light of the observations made during the years 1962 and 1963. It has been noticed that there is a considerable increase in the percentage of winged forms following partial starvation of the immature insects. Partial starvation was induced in three ways : (*i*) delayed innoculation ; (*ii*) use of uncommon host plants; and (*iii*) use of common host plants made unsuitable by avoiding prunning. The occurrence of winged forms in the winter crops *i.e.* the *Katki* and *Agahni* crops are reported for the first time.

57. The PAS reactive substances of the cytoplasmic organelles in the developing male germ cells of *Lygaeus hospes* (Heteroptera).

S. N. Srivastava, *Lecturer in Zoology, L. S. College, Muzaffarpur.*

A neutral nonsulphated mucopolysaccharide was detected in the Golgi internum of the primary spermatocytes and also in the acroblast and the acrosomes of the early and late spermatids respectively. The PAS reactive substance of the acrosome showed the presence of protein also, so firmly united with it that a pepsin sol. of the strength 1% was unable to split them. The PAS reaction was negative in the mitochondria of the spermatocytes and in the nebenkern of the spermatid. The protein found in the mitochondria and in the nebenkern was in a higher concentration than that found in the acrosome and was also easily digested with the pepsin sol. employed. No lipid was detected in the Golgi internum and in the acrosome, but the Golgi externum, the shall of the acroblast and the mitochondria and the nebenkern showed the presence of lipid.

Hence these two catagories of the cytoplasmic inclusions of the developing male germ cells, namely, the Golgi bodies and the mitochondria are cytochemically different.

58. On the structure of the Pecten of the Cattle-egret *Bubulcus ibis.*

P. N. MEHROTRA AND P. B. SINHA, *Department of Zoology, Ranchi University, Ranchi.*

The microsopic anatomy and physiology of the pecten of the birds have not been studied well and this structure still presents problems which are obscure. The pecten of the cattle-egret is mainly composed of small blood capillaries bound by a hyaline limiting membrane and lined with a single layer of a typical endothelial cells whose cell boundaries are not distinct. In between the capillaries can be seen small cells occasionally stellate though generally round, each with a spherical deeply staining centrally situated nucleus. The cytoplasm of these cells is loaded with 50–100 pigment granules of varying sizes. The black colour of the pecten is due to these pigment cells. The main artery which supplies the pecten lies near the upper part of the pecten and divides into several branches each supplying a fold of the pecten. Venules come from each fold of the pecten and join to form a main vein which runs side by side with the main artery. There are no sensory hairs or end bulbs in the pecten.

The authors do not agree with the view that the pecten is a portion of the choroid coat which has passed through the foetal fissure and proliferated inside the eye. The blood supply of the pecten is connected with the vessels in the optic nerve and not with the choroidal vessel. Whereas the vessels in the pecten are lined by a single layer of flattened endothelial cells, the endothelium in the choroid is more than one cell thick. Futher the capillaries of the pecten have a hyaline limiting membrane which is absent in the choroid. The pigment granules in the choroid are much smaller than those of the pecten and are present in such large numbers so as to completely hide the nucleus.

Whereas some authors believe that the pecten represents the arteria-centralis-retinae and nourishes the vitreous humour, others state that it is probably involved in the mechanism of accommodation. We agree with the view that the pecten should be looked upon as a modification of the intraocular vascular arrangements having special reference to the increase in the efficieny of in the eye.

59. Quantitative Studies on the Interstitial cells of the Testes of *Anser melanotus* **(Aves, Anseres).**

P. N. MEHROTRA, *Department of Zoology, Ranchi University, Ranchi.*

The studies on the interstitial cells of birds have so far been of a qualitative nature only and no attempts have been made to estimate the quantitative changes in the interstitial cells. Further, whereas many investigators have recorded a marked parallelism between interstitial cell cycle and cyclical changes occurring in the seminiferous tubules, in other cases a marked antagonism between the two has been reported and in a few cases any periodicity in the interstitial cells has been completely denied. The present paper gives an account of interstitial cell cycle in the testes of *Anser melanotus.*

The radius of a particular field under the microscope was measured by an ocular micrometer and as the thickness of each section was known, the volume of the field in view could be calculated. The number of interstitial cells present in each field was counted. About thirty to forty fields representative of each month were examined and the mean figure of interstitial cells per field calculated.

$$\text{Total number of interstitial cells per testis} = \frac{\text{Volume of testis} \times \text{Mean no. of cells per field}}{\text{Volume of the field}}$$

With the overall enlargement of the testis volume and the ripening of the tubules, there is an accompanied increase in the number of interstitial cells. It is true that with enormous expansion of the seminiferous tubules, the closely packed interstitial cells of the resting testis get dispersed in the intertubular spaces and thus relative to the spermatogenic cells they look fewer but there is undoubtedly an enormous increase in their absolute quantity.

In *Anser melanotus* the interstitial cells have their maximum number in February (testis volume—397525 cu.mm.; number of interstitial cells—331,270833) when the birds are at the peak period of their sexual activity. In May—June which mark the end of the Regressive phase and the beginning of the Refractory phase, the number of interstitial cells present is minimum (testis volume—10267 cu.mm. ; number of interstitial cells 20,534000). There is again a progressive increase in the number of interstitial cells till the maximum is reached in February. Thus my observations conclusively establish that the interstitial cells undergo periodic increase in their quantity parallel to the spermatogenic activity of the testis tubules.

60. Studies on storage rot fungi—III. Utilization of amino acids in mixture.

S. N. BHARGAVA, *Botany Department, University of Allahabad, Allahabad.*

The utilization of the mixtures four different amino acids (Mixture No. 1-L-leucine + DL – tryptophane + L – glutamic acid and DL – aspartic acid, Mixture No. 2 – DL – phenylalanine + DL – methionine + L – histidine + DL – alanine, Mixture No. 3 – L – leucine + DL – methionine DL – alanine +L – arginine and Mixture No. 4 – DL – valine + L – proline + L – histidine + DL – serine) by three storage rot fungi *viz.*, *Fusarium solani* (Mart.) App. and Wr., *Botryodiplodia ananassae* (Sacc.) Petrak and *Macrophomina phaseoli* (Maubl.) Ashby was studied chromatographically.

Mixture No. 1 containing leucine + tryptophane + aspartic and glutamic acids supported best growth of three fungi under study. In case of *F. solani* and *B. ananassae* it was followed by Mixtures 4, 2 and 3 while in case of *M. phaseoli* Mixture No. 3 was better than Mixture No. 2.

It was found that some of the amino acids which were utilized slowly from one mixture were utilized preferentially when present in another mixture. Both poor and good amino acids were utilized simultaneously from a mixture.

All the organisms first lowered the pH of the culture medium and then drifted towards the alkaline side.

61. Studies on storage rot fungi—IV. Free amino acids of mycelium.

S. N. BHARGAVA, *Botany Department, University of Allahabad, Allahabad.*

The presence of free amino acids in the mycelium of the three storage rot fungi *viz.*, *Fusarium solani* (Mart.) App. and Wr., *Botryodiplodia ananassae* (Sacc.) Petrak and *Macrophomina phaseoli* (Maubl.) Ashby causing dry rot of Gladiolus bulbs, fruit rot of pineapple and charcoal rot of potato tubers respectively, was investigated.

It was observed that aspartic and glutamic acids, serine, glycine, alanine, proline, glutamine and γ-amino butyric acid were common in all the three fungi while arginine, tryosine, valine, leucine and isoleucine were present in *F. solani* and *B. ananassae*. Threonine was only observed in case of *F. solani*. Five unknown amino acids were also detected during the investigation but their presence varied.

62. Studies on storage rot fungi—V. Utilization of oligo- and poly saccharides.

S. N. BHARGAVA, *Botany Department, University of Allahabad, Allahabad.*

The utilization of various oligo- and poly-saccharides by *Fusarium solani* (Mart.) App. and Wr., *Botryodiplodia ananassae* (Sacc.) Petrak and *Macrophomina phaseoli* (Maubl.) Ashby was studied chromatographically.

Present organisms utilized sucrose, maltose, cellobiose, starch and inulin through hydrolytic and lactose through non-hydrolytic pathways. *F. solani* only utilized melibiose and raffinose through a non-hydrolytic pathway. Trehalose and melezitose were partially consumed through a non-hydrolytic pathway by *F. solani* and *B. ananassae* while *M. phaseoli* consumed melezitose fully and trehalose partially through a hydrolytic pathway. Synthesis of additional oligosaccharides were detected in the culture media containing maltose, cellobiose and starch when they were utilized by the present forms. Oligosaccharides were also formed during the utilization of melibiose and raffinose by *B. ananassae* and of melibiose, melezitose and inulin by *M. phaseoli*. The Rf values of various oligosaccharides formed during utilization of di-, tri-, and polysaccharides have been recorded. The dry weight could not be correlated with the rate of utilization. It was further observed that the growth of these fungi on various oligosaccharides may or may not be similar to that on their hydrolytic products.

63. Further Studies on the Effect of Concentration of Nitrogenous Salts on the Formation of Heterocysts in the Cyanophyta.

A. K. MITRA, *University of Allahabad, Allahabad.*

The specialised cells known as "Heterocysts" found in several filamentous members of the Cyanophyta are very widespread and characteristic but their exact function is not known. Fritsch (Presidential Address, Linn. Soc. London, 1951) has called these "Botanical Enigma" and Geitler (1960) has expressed the opinion that the hypothetical functions assigned to heterocysts have not been satisfactorily explained. This is due to the theories about their functions being advanced through observations on materials collected from nature and lack of adequate data on their formation under controlled experimental conditions.

Canabaeus (1929) reported increase in the numbers of heterocysts when grown on 2% NaCl but this could not be confirmed with the algae tested here. Fogg (1949) concluded that the frequency of heterocysts was inversely related to combined nitrogen in the filament. Mitra (Ph.D. Thesis, University of London, 1947) observed total absence of heterocysts when grown on a medium with excess of nitrate and recently Pandey and Mitra (1962) showed depletion of nitrogen below a critical concentration alone resulted in the formation of heterocysts. Results presented here show that several other normally heterocystous members of Cyanophyta belonging to different families show a heterocystless condition so long as the level of nitrogen in the medium does not fall below the critical concentration.

64. Studies on the effect of micro elements on the seed germination and growth of the seedlings of Barley (*Hordeum vulgare* L.).

NIRANJAN DAS AND R. S. L. SRIVASTAVA, *Department of Botany, University of Allahabad, Allahabad.*

A study on the effect of presowing treatment with different concentrations of micro elements was conducted in barley (*Hordeum vulgare* L. Variety C 251). The micro elements used were Cu, Mn, Zn, Bo and Mo. Solutions of 0·01%, 0·02%, 0·03%, 0·04%, 0·05%, 0·08%, 0·16%, 0·32%, and 0·64% of each of the above micro elements were prepared and seeds were treated for twenty-four hours. A control was also run. Percentage of germination and total length of root and shoot were recorded daily for five days.

The above studies showed that maximum percentage of germination took place in solutions of 0·03% in Cu, 0·08% in Mn, 0·04% in Zn, 1·04% in Bo, 0·05% in Mo. The rate of germination was lowest in control as compared to the rate of germination in the above concentration of solutions. The germination on the fifth day was 78·6% in control, 86·7% in Bo. 90% in Mo, 92·5% in Zn, 94·7% in Cu, 97·5% in Mn indicating thereby that treatments with micro elements enhanced the rate of germination which was highest in Mn treatment and lowest in the control. The trend in the rate of germination was the same in all the treatments from the first day.

A daily record of the root and shoot length during first five days showed that, in general, there was maximum growth in the length of root and shoot in those treatments in which maximum germination took place and in all these cases growth of the seedlings were higher than control. It has also been observed that at higher concentrations there has been a depression in the length of root and shoot in all the treatments and this became more pronounced with the passage of time. It may be concluded that the micro elements play an important role in influencing the rate of germination and also in increasing the root and shoot length in the early stages of the germination of the seedlings.

65. Studies on the effect of micro elements, ammonium sulphate and their combinations on germination and growth of the seedlings of *Zea mays* L.

R. S. L. SRIVASTAVA AND NIRANJAN DAS, *Department of Botany, University of Allahabad, Allahabad.*

A study on the effect of presowing treatment with solutions of 0·01%, 0·02%, 0·03%, 0·04%, 0·05%, 0·08%, 0·1%, 0·16%, 0·32% and 0·64% of Cu, Mn, Zn, Bo, Mo and ammonium sulphate were performed in *Zea mays* L. Var. C 41. Seeds were soaked in each of the above solutions for twenty-four hours and a control was also run. Percentage of germination and total length of root and shoot were measured daily for five days. Later on another set of experiment was performed in which seeds were treated with 0·03% Cu, 0·05% Mn, 0·04% Zn, 0·04% Bo, 0·05% Mo in combination with 0·1% of ammonium sulphate with each of the above solutions ; these being the concentrations at which best germination and growth took place when treated separately.

The rate of germination was highest (85·3% on the 5th day) in Mn treatment and lowest (68·2% on the 5th day) in the control. When ammonium sulphate was given along with the micro elements, it was observed that combinations of micro elements and ammonium sulphate showed better germination but less growth of the seedlings as compared to control. In general, there was maximum growth in the length of root and shoot in those treatments in which maximum germination took place and in all these cases growth of the seedlings was better than control and ammonium sulphate. At higher concentrations there has been a depression in the length of root and shoot and this became more evident with the passage of time.

Micro elements had better effect in increasing the root and shoot length in the early stages of germination of the seedlings as compared to ammonium sulphate and control. The concentrations which were helpful in increasing the percentage of germination as well as the growth of the seedlings when applied separately ; proved to be detrimental when given in combination with ammonium sulphate, in all cases as far as growth of the seedlings was concerned.

66. Readjustment of cropped area among wheat, Barley, Gram and Mustard in the Union for more profit.

AMAR SINGH AND R. A. SINGH, *Botany Department, University of Allahabad, Allahabad.*

Wheat (NP 52), Barley (C 294), Gram (T 87) and Mustard chosen for the present study were grown in pot cultures. Observations for growth and development of the plants were conducted at an interval of one month. Calculations with regard to the nutritional efficiency were done on the basis of the results obtained.

Early germination in wheat and delayed in gram as well as mustard were noted. Tiller number in barley was higher than that in wheat. Maximum expansion of leaf was found at the beginning of reproductive stage in each case except in gram in which case increased leaf number at the onset of the reproductive phase was noted, (no leaf area being studied in this case). The rate of dry matter accumulation was found to have increased tremendously as the plants were passing through flowering stage.

The highest amount of plant nitrogen, calculated on oven dry basis, was recorded in the early stage of the plants. It decreased progressively to minimum at harvest. The growth of wheat plants brought about least change in pH of medium of growth (soil) while maximum deviation was recorded by gram plants.

Gram grains were found to be rich in both crude proteins as well as digestible protein, followed by wheat and barley for the crude and barley and wheat for the digestible, in decreasing order. The total nutritive value of the crops was evaluated on the basis of proportional acreage (1952) of the crops in the Indian Union.

The data obtained have been utilized to determine the proportionate acreage under the four important *Rabi* crops for increased energy and digestible protein. The proportionate acreage in India at the time was 4·07 : 1·20 : 2·13 : 1·0 as between wheat : barley : gram mustard, taking the area under mustard to be unity. This acreage could be profitably redistributed among the four crops,

wheat, barley, gram and mustard, as 6·0 : 5·4 : 6·0 : 1 for obtaining more energy and digestible protein. In the readjusted acreage the energy and digestible protein values are increased to 1907 and 2024 respectively as against 1824 and 1854 under the existing acreage. This net increase of 83 and 171 for energy and digestible protein respectively can be utilised to the partial yet effective and practical solution of food problem of India. Similar effective measures could be taken up for other crops too, based on scientific studies.

67. Dry matter accumulation and chemical composition of *Linum usitatissi-mum* **(var. T₄₇₇) during its ontogency.**

AMAR SINGH AND RAJ MANI PANDEY, *Botany Department, University of Allahabad, Allahabad.*

Randomised block lay out method was followed with six blocks each having five plots. Seeds were sown, the attributes of growth and chemical components noted fortnightly. Before sowing, the soil of the field was analysed for its chemical status with respect to calcium, magnesium potassium, nitrogen and also hydrogen-ionconcentration.

Dry matter was found to increase throughout the life cycle of the plant. Fresh weight, considered on the basis of dry matter, was produced maximum at the age of 15 days, it decreased towards the end of the life cycle. Percentage of moisture, on dry weight basis, was found to decrease from 30-day age to the end of the life cycle, but it was found to increase between 15 to 30 day-age. The total absolute value of ash which increased with age when considered on the basis of percentage of dry weight was maximum at 15-day age and minimum at the age of 120 days.

The percentage of protein was maximum at the 105 day–age, decreasing at the age of 120 days ; the value was more or less constant during the 45 to 75 day-age period, an increase was noted from 15 to 30 days. In vegetative organs the fall was noticed from 75 day-age to 120 day-age. In reproductive organs it increased from 75 to 90 days.

Phosphorus increased with age. In vegetative organs it was maximum at 15 day-age. Later a decline was noticed towards the end at 105 days, after which it again increased at the 120 day-age. In the reproductive organs percentage of phosphorus was maximum at the age of 75 days, later a fall was noticed.

The percentage of total sugar in entire plant was maximum at the age of 105 days. Between 15 to 105 days its irregular rise and fall was noticed. In vegetative organs maximum percentage of total sugar was recorded at the age of 105 days, but in reproductive organs it was maximum at 90 day-age. The percentage reducing sugar on dry weight basis showed an irregular rise and fall. It was found to be maximum at the age of 30 days. In vegetative as well as reproductive organs a continuous fall in the values was noticed from 75 to 120 day-age.

The total absolute value of fat was found to increase at all the three differ-ent stages with the exception of the vegetative organs where it was found to

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decrease between 90 to 105 days. Its maximum value was found at the age of 90 days. Later, the values were more or less constant towards the end of life cycle. In vegetative organs maximum percentage was obtained at 90 days and this was also true with reproductive organs. From 90 days onwards, in vegetative organs the values were found to decrease, but in reproductive organs it decreased at 105 days but to rise again at the age of 120 days.

68. A comparative study of the deterioration of the wheat grain in various types of storage system.

AMAR SINGH AND D. C. BEOHAR, *Botany Department, University of Allahabad, Allahabad.*

Seeds were collected from various places from different types of storage systems i.e., *Kotha* (Godowns), *Khatti* (underground pits), *Khondia* (underground pits of M. P.), *Kothi* (earthen bins) and *Dholi* (small structure).

The moisture content of the samples from *Khondia* system was recorded to be the least followed by *Kotha, Dholi, Kothi* and *Khatti*. Reducing and non-reducing sugars were highest in samples of *Khatti* system and lowest in that of *Khondia* system. Vitamin B_2 was found highest in the sample from *Kothi* system followed by *Dholi, Kotha, Khondia* and *Khatti* in succession.

Samples from *Khondia* system gave the highest percentage of germination which was followed by the *Khatti, Kotha, Dholi* and *Kothi* in order. Volume-weight was also recorded in the same order. The purity percentage of the samples from *Dholi* and *Kothi* systems were better to be followed by that in *Khondia, Khatti* and *Kotha*. The conditions of no-light and red-light had no marked effect on the germination percentage of the wheat seeds and its viability. Samples from the *Kothi, Kotha, Khatti* and *Dholi* systems were found to be attacked by stored grain pests.

According to these studies *Khondia* system was found to be the best followed by the *Kotha, Dholi, Kothi*, and the *Khatti*. *Pakka Khattis* proved better than *Kachcha Khatti*. It was thus seen that the systems of storage prevelent in the different parts of Uttar Pradesh and Madhya Pradesh have good deal of variability as to their efficiency.

69. Changes in Organic matter, nitrogen, nitrate nitrogen, water holding capacity and moisture in sandy loam soil green manured by Crotalaria juncea.

AMAR SINGH AND NARENDRA PAL, *Botany Department, University of Allahabad, Allahabad.*

Field investigations were conducted with randomised block design. The field was ploughed twice after turning the green manure to aid complete decomposition. The soil was analysed after 15 days of turning in plants of sunn-hemp.

Maximum value of organic matter was recorded in beginning of September, i.e., 15 days after turning of green manure, but after 135 days it decreased considerably. Total nitrogen content increased for about two months after ploughing in of the plants. Minimum addition of nitrogen was noticed in the beginning, while maximum on 65 days after which a decline was again evidenced.

Nitrate nitrogen increased gradually and maximum was attained 135 days after the incorporation of *Crotalaria* plants into the soil. With ploughing nitrate nitrogen decreased.

Water holding capacity of the soil increased by about 7% during 135 days of period of study. With each ploughing water holding capacity decreased but increased later on.

It was evident that total nitrogen, nitrate nitrogen, water holding capacity increased while organic matter and moisture of air dry soil decreased in the later stages of the observations.

70. Effect of Urea and Sulphate of Ammonia singly and in combination on growth, composition and yield of *Triticum aestivum* (var. C_{13}.).

AMAR SINGH AND H. C. SRIVASTAVA, *Botany Department, University of Allahabad, Allahabad.*

Investigations were conducted in the randomised block design with three treatments and four replicates in the field. Seeds of wheat (C_{13}) were sown at the rate of 30 kg per acre. Urea and sulphate of ammonia were applied at the rate of 15 lb/acre separately. The mixture of these two was used each at the rate of $7\frac{1}{2}$ lb N/acre. Variations in growth attributes of six plants from each plot were recorded at an interval of 15 days.

Tillering capacity of the plants increased with the application of nitrogen but the combination treatment proved optimum. Maximum leaf number was recorded in the plants receiving the mixture dose ; urea showed better effect than sulphate of ammonia. The number of dry leaves was remarkably higher in control. Whereas application of urea increased leaf area to maximum the mixture combination produced more leaf area than sulphate of ammonia. Linear growth of the plants increased under all the treatments, the maximum being attained with sulphate of ammonia. The mixture combination induced greater accumulation of plant proteins and also of ash besides maximum yield. The dry matter of the leaves, number of ears, absolute weight of the grains, grain/ear ratio and finally yield of both grain and straw.

Urea and also sulphate of ammonia each applied singly increased protein content of grains. All nitrogen applications increased protein content of grains and sugar content of plants. Urea augmented maximum dry matter of the stem, produced more ears than sulphate of ammonia applied alone.

Sulphate of ammonia increased ear-length (as also in the case of fertilizer mixture) and no. of grains/ear. Grain yield under the suphate of ammonia as well as urea treatments remained unaffected. The fat content of the grains remained unaffected by the nitrogen treatments.

71. Foliicolous Fungi from Allahabad—I.

SUDHIR CHANDRA AND R. N. TANDON, *Botany Department, University of Allahabad, Allahabad.*

In this paper 34 foliicolous fungi collected by the authors from various localities of Allahabad during last two years are described. The hosts and pathogens included in the paper are listed in the following table. Some new species have recently been described by authors and they are marked with ' + '. Those marked

with ' ++ ' are new species which will be described and published in due course. While those marked with ' * ' are new fungus records for the country. The remaining ones have been recorded on new hosts.

Host	Family	Causal organism
Adina cordifolia Benth. and Hook. f.	Rubiaceae	+*Phyllosticta halduana* Chandra and Tandon
Acacia sp.	Leguminosae	*Hendersonula toruloides* Nattrass
Arundo donax L.	Gramineae	*Helminthosporium spiciferum* (Bainier) Nicot
Agave americana L.	Amaryllidaceae	+*Sirodesmium indica* Chandra and Tandon +*Sphaeronema allahabadensis* Chandra and Tandon
Begonia amaena L.	Begoniaceae	*Colletotrichum capsici* (Syd.) Butl. and Bisby *Curvularia verruculosa* Tandon and Bilgrami
Caladium bicolor Vent.	Araceae	*Colletotrichum capsici* (Syd.) Butl. and Bisby
Coleus sp.	Labiatae	*Fusarium avenaceum* (Fr.) Sacc.
Cannabis sativa L.	Urticaceae	*Papularia sphaerosperma* (Pers. ex Fr.) Hohnel *Chaetomium succineum* Ames.
Caryota urens L.	Palmae	*Pestalotia vismiae* Petrak ++*Phyllosticta* sp. nov.
Chlorophytum sp.	Liliaceae	++*Colletotrichum* sp. nov.
Celosia cristata L.	Amaranthaceae	*Malustela aeria* Batista, Lima and Vasconcelos
Cassia sp.	Leguminosae	*Alternaria tenuis* Nees ex Pers.
Cassia fistula L.	Leguminosae	*Alternaria cassiae* Jurair and Khan *Curvularia verruculosa* Tandon and Bilgrami +*Phyllosticta amaltasia* Chandra and Tandon
Eichhornia speciosa Kunth.	Pontederiaceae	*Curvularia lunata* (Wakker) Boedijn
Eugenia jambolana Lamk.	Myrtaceae	*Colletotrichum gossypii* Southw.
Ehretia acuminata Br.	Boraginaceae	*Malustela aeria* Batista, Lima and Vasconcelos ++*Phoma* sp. nov.
Euphorbia royleana Boiss.	Euphorbiaceae	*Glomerella cingulata* (Stonem.) Spauld. and Schrenk.
Eucalyptus citriodora Hook	Myrtaceae	*Curvularia verruculosa* Tandon and Bilgrami *Cylindrocladium theobromi* Booth

Host	Family	Causal organism
Elettaria cardamomum Maton	Scitamineae	*Curvularia verruculosa* Tandon and Bilgrami *Glomerella cingulata* (Stonem.) Spauld. and Schrenk.
Gardenia florida L.	Rubiaceae	*Sordaria bosensis* Das +*Phoma garflorida* Chandra and Tandon ++*Pyrenochaeta* sp. nov. **Helminthosporium hawaiiense* Bugnicourt
Ficus glomerata Roxb.	Urticaceae	*Thielavia sepedonium* Emmons
Hamiltonia suaveolens Roxb.	Rubiaceae	*Curvularia geniculata* (Tracy and Earle) Boedijn.

72. Foliicolous Fungi from Allahabad—II.

SUDHIR CHANDRA AND R. N. TANDON, *Botany Department, University of Allahabad, Allahabad.*

The second paper of the series records 38 species of fungi causing leaf spot diseases at Allahabad. Two new species have recently been described while seven others are also new forms. Their detailed description will follow. All of these are marked with ' + '. Species marked with ' * ' are new fungus records. All the others are new host record.

Host	Family	Casual organism
Ixora parviflora Vahl.	Rubiaceae	+*Phoma* sp. nov. +*Phyllosticta* sp. nov.
Impatiens balsamica L.	Geraniaceae	*Malustela aeria* Batista, Lima and Vasconcelos +*Phoma* sp. nov. *Chaetomium globosum* Kunze
Kigelia pinnata DC.	Bignoniaceae	*Glomerella cingulata* (Stonem.) Spauld. and Schrenk *Fusarium semitectum* Berk and Rav. *Curvularia verruculosa* Tandon and Bilgrami +*Phyllosticta* sp. nov.
Lilium sp.	Liliaceae	+*Phoma* sp. nov.
Murraya exotica L.	Rutaceae	*Colletotrichum capsici* (Syd.) Butl. and Bisby *Alternaria tenuis* Nees ex Pers. +*Phyllosticta murrayae* Chandra and Tandon

Host	Family	Casual organism
Milletia ovalifolia Kurz.	Leguminosae	*Curvularia verruculosa* Tandon and Bilgrami *Alternaria tenuis* Nees ex Pers. *Fusarium semitectum* Berk. and Rav. *Glomerella cingulata* (Stonem.) Spauld. and Schrenk
Nauclea cadamba L.	Rubiaceae	*Malustela aeria* Batista, Lima and Vasconcelos *Glomerella cingulata* (Stonem.) Spauld. and Schrenk
Notonia grandiflora DC.	Compositae	*Colletotrichum dematium* (Pers. ex Fr.) Grove *Colletotrichum gloeosporioides* (Penz.) Sacc.
Nyctanthes arbor-tristis L.	Oleaceae	*Curvularia fallax* Boedijn *Alternaria tenuis* Nees ex Pers.
Plumeria alba L.	Apocyanaceae	*Phyllosticta plumierae* Tassi
Sapindus trifaliatus L.	Sapindaceae	+*Colletotrichum* sp. nov. *Glomerella cingulata* (Stonem.) Spauld. and Schrenk *Fusarium acuminatum* Ellis and Ev. *Aspergillus nidulans* (Eidam) Wint.
Tinospora cordifolia Miers	Menispermaceae	*Curvularia verruculosa* Tandon and Bilgrami
Tectona grandis L. f.	Verbenaceae	+*Phomopsis* sp. nov. *Glomerella cingulata* (Stonem.) Spauld. and Schrenk *Curvularia verruculosa* Tandan and Bilgrami
Tamarindus indica L.	Leguminosae	+*Phyllosticta tamarindina* Chandra and Tandon
Vitis vinifera L.	Vitaceae	*Glomerella cingulata* (Stonem.) Spauld. and Schrenk
Anona Squamosa L.	Anonaceae	*Glomerella cingulata* (Stonem.) Spauld. and Schrenk *Malustela aeria* Batista, Lima and Vasconcelos *Helminthosporium rostratum* Drechsler *Botryosphaeria ribis* (Gros.) Dugg. var. nov.

73. The effect of the application of nitrogenous and Phosphatic fertilezers on the composition and yield of *Triticum aestivum* (C_{13}) singly, and in combination.

AMAR SINGH, AND J. R. SINGH, *Botany Department, University of Allahabad, Allahabad.*

Investigations were conducted in randomised block design with four replicates and four treatments, *i.e.*, control, (N), (P) and (N + P). The rate of fertilizer application being nitrogen at 60 lb per acre and phosphorus at 40 lb of P_2O_5 acre, Sulphate of ammonia formed the source of nitrogen and superphosphate that of phosphorus.

Total nitrogen of the plants was noticed to increase till the heading stage after which it declined except in the nitrogen treated series. Under nitrogen and in mixture (N + P) treatment, the nitrogen percentage was observed increasing from vegetative stage to heading and then up to the milky grain stage. Phosphorus application continued to increase its content in plant at all the stages. The value of potassium decreased from vegetative to milky grain stage except in the control and nitrogen treatments. In later stages higher amount of potassium was found. Fertilizer mixture was the best in increasing the potassium content. The application of nitrogen showed a continuous rise in calcium percentage of the plants as the plants advanced in their age.

Nitrogen application showed maximum tissue moisture at the vegetative and milky grain stage whereas at heading, phosphorus recorded maximum.

Maximum yield of grain and straw on acre basis was recorded in the nitrogen-phosphorus mixture application. Phosphorus application recorded a higher yield of grain, though not of straw when compared to nitrogen application.

74. The effect of time of application of phosphorus on growth, yield and composition of *Arachis hypogea* (var. T_{25}).

AMAR SINGH, AND R. LAKHAN, *Botany Department, University of Allahabad, Allahabad.*

These investigations were conducted in accordance with the randomised block lay-out technique. Sowing of the seeds was done at the rate of 30 lb/acre. Phosphorus was supplied as supperphosphate containing 29·32% P_2O_5 at the rate of 20 lbs of P_2O_5/acre in either application twice. The plants were given the first treatment (P_1) at the age of 50 days and the second (P_2) one month after flowering, *i.e.*, at the age of 80 days.

The studies of various growth characters as manifested by the number of leaves, branches and also flowers/plants were made every 15 days.

Leaves and nuts were analysed chemically for protein and fats. Number of leaves, number of branches and length of branches were found to increase with age irrespective of treatments. P_1 gave best results followed by P_2 and control in succession. Phosphorus tended to produce larger number of flowers as compared to the control.

A slight increase in the percantage of nitrogen in leaves was recorded at 50 days age of the plants which later decreased with age, in all treatments. The magnitude of decrease was maximum in P_1 followed by P_2 and control in succession. Similar effects were noticed in the protein content also. The rate of increase in percentage of fat was fastest in P_1 followed by P_2 and control in order.

Dry matter accumulation in the leaves as well as in nuts was greater in P_1 than in P_2 which in its turn proved superior to control.

It may be concluded that application of phosphorus was beneficial to *Arachis hypogea* irrespective of time of application, though better results were obtained when applied early in the life of the plant.

75. A comparison of the growth behaviour, composition and yield of *Phaseolus radiatus* (Moong Type 1) raised under nitrogenous and phosphatic fertilizers.

AMAR SINGH AND R. B. SINGH, *Botany Department, University of Allahabad, Allahabad.*

Investigations were conducted in the plots randomly laid out. The crop was sown in alternate blocks leaving one block fallow in between two blocks and fertilizers were applied at the rate of 15 lbs per acre of nitrogen as well as phosphorus in the form ammonium sulphate and superphosphate. Observations for various growth attributes and estimations of the chemical component were made every fortnight.

Per cent tissue-moisture decreased with the advance in age of the plants. In early stage, there was insignificant difference in this character between nitrogen and phosphorus treatments, though towards the end of the life cycle of the plant nitrogen treated plants possessed significantly higher percentage of tissue-moisture.

Dry matter percentage increased with age. There was no marked difference in the accumulation of dry matter in the plants of nitrogen and phosphorus series at the age of 35 days. Towards the end of the life cycle phosphorus treated plants accumulated a higher percentage of dry matter than nitrogen treated ones.

In the earlier stages as well as at the time of harvest phosphorus treated plants had higher percentage of ash than nitrogen treated ones. Similar trend was exhibited in respect of carbohydrates also. Nitrogen percentage was found to increase with the advance in age in both nitrogen as well as in phosphorus treated plants. Nitrogen proved much superior than phosphorus in this respect. A slightly higher percentage of carbohydrate was noticed in nitrogen treated plants than in phosphorus treated ones.

No significant difference was recorded in percentage of phosphorus in both nitrogen and phosphorus treated plants. At the last observation phosphorus treated plants possessed comparatively a higher percentage of phosphorus than the nitrogen treated ones. Shoot-root ratio was greater in nitrogen treated plants.

There was no significant difference in the grain yield between nitrogen and phosphorus treatments while a higher straw yield was recorded in nitrogen series as compared to the phosphorus series.

It was concluded that the small dose of fertilizers (N & P) neither affeted the plant composition markedly nor the grain yield of *Moong* type 1 plants.

76. The effect of the applications of nitrogen and of phosphorus at three levels on the composition, yield and respiration of *Brassica alba* (var. T_1) plants and on cartain changes in the soil.

AMAR SINGH AND J. S. SINGH, *Botany Department, University of Allahabad, Allahabad.*

Studies were conducted in pots containing soil fertilized with nitrogen in the form of ammonium nitrate and phosphorus in the form of monocalcium phosphate. Separate additions of nitrogen and phosphorus were made at 10 lb/acre in one series and at 25 lb/acre in the other. Six pots were kept fallow in each series and in third series of pots no fertilizer was added. Observations were made at an interval of 15 days.

Nitrogen application at both the levels increased the rate of respiration as against the control of the same age, the response being more pronounced up to the age of 85 days. Phosphorus applications lowered the rate of respiration. Nitrogen treated plants showed more fresh weight up to 115 days while phosphorus affected the plants in reverse fashion. Nitrogen slightly lowered the dry matter accumulation while phosphorus increased it. Nitrogen supply at 10 lb/acre (N_1) had no effect on ash content while at 25 lb/acre (N_2) caused a reduction in ash content. Phosphorus applications on the other hand increased the ash content.

Nitrogen applications decreased the phosphorus content of the plants while phosphorus applications increased it. Nitrogen resulted in slight reduction of sugar content while it was greatly reduced by phosphorus treatments. Protein content was appreciably increased in the nitrogen treatments while phosphosus decreased it. Nitrogen slightly retarded fat accumulation while phosphorus applications stimulated it.

N_1 resulted in an increase of 6 lb/acre of the seed yield while N_2 increased it by 2 lb/acre only. P_1 resulted in an increase of seed yield to 681 lb/acre and P_2 to 96 lb/acre.

Initial pH of the soil was maintained on the last date of experimentation in the fallow, while it was lowered in the cropped soils. Nitrogen application resulted in a slight increase in hydrogen ion concentration while phosphorus applications resulted in a decrease of the concentration of hydrogen ions both in fallow and cropped soils. Nitrogen additions resulted in increased nitrogen percentage of the soil and increased its absorption by the plants while phosphorus applications retarded its absorption. Phosphorus level was reduced in fallow soils up to the final date. Nitrogen applications resulted in a decrease in absorption of phosphorus by plants while phosphorus additions increased its percentage in the soil and also its absorption.

It might be suggested, therefore, that the use of phosphatic fertilizers is of greater advantage for an oily crop like the mustard.

77. The growth behaviour and yield of *Triticum aestivum* (C_{13}) as affected by the application of nitrogenous and phosphatic fertilizers.

AMAR SINGH AND S. K. KUSHWAHA, *Botany Department, University of Allahabad, Allahabad.*

Studies were made in randomised block design with four replicates and four treatments. Sulphate of ammonia and super-phosphate were applied singly and in combination along with a control to supply 60 lbs of nitrogen and 40 lbs of P_2O_5 per acre,

The treatments had a significant effect on the height of the plants. Relatively greater increase in height was noticed with nitrogen treatment than the rest of the treatments. Tillering increased up to booting stage in both control and phosphorus treated series while it proceeded to preflowering stage in nitrogen and in mixture treatment. Greater number of production and survival of tillers was noticed in the mixture treatment. Relatively higher number of leaves were produced by phosphorus treatment at booting stage than in nitrogen treated ones, but the former were unable to retain greater number of leaves at the flowering stage in comparison to the latter.

Maximum expansion in the assimilatory leaf surface was found in the nitrogen treatment. Increase in surface area was noted up to preflowering stage in phosphorus and control, while it continued up to flowering in nitrogen, and nitrogen-phosphorus mixture.

Nitrogen increased the chlorophyll content throughout the life cycle of the plants. Maximum amount of pigment was present in (N+P) mixture treatment at the flowering stage. Phosphorus brought about early-flowering while nitrogen delayed the same.

Maximum number of ears per plant, straw and grain yield per acre were noticed in the combined nitrogen-phosphorus treatment while maximum length of ears and number of spikelets per ear in the nitrogen fed plants. Maximum test weight of grains was noted in phosphorus treated series. Nitrogen exhibited a relatively higher straw grain ratio as compared to phosphorus treatment.

78. The influence of boron on growth, chemical composition, yield, nodulation and fixation of nitrogen in Phaseolus radiatus (Moong T_1).

AMAR SINGH AND Y. V. CHADDHA, *Botany Department, University of Allahabad, Allahabad.*

Seeds of Moong type 1 were sown in pots containing acid and water washed coarse sand. The earthen pots were coated with bituminous black paint. Pots were supplied with nutrient solution excluding boron. 0·5 ppm (B_1) and 1 ppm (B_2) boron concentrations were supplied and a *minus* series served as a control. Growth observations and chemical estimations were made at an interval of 15 days.

Vertical growth of the plants as well as root length was maximum ia 0·5 ppm concentration 1 ppm produced toxic effect. Leaf area was also maximum in 0·5 ppm treated at all the stages. The Maximum dry matter accumulation was found in 0·5 ppm concentration. In both the boron concentrations of 0·5 ppm and 1 ppm, ash content was lower than control.

Roots as well as shoots of the control plants had the higher content of nitrogen as compared to the treated ones. Boron application reduced nitrogen content of shoot, root and also nodules effectively.

The percentage of total sugars was more in 0·5 ppm treated plants than control and 1·0 ppm treated plants, but the starch content of the tops as well as the roots found more in control than boron treated plants. An increase in the nitrogen content in nodules was found in the control and the number of nodules increased though accompained by the reduction of nodular weight and vice-versa.

Higher yield of grains was obtained in 0·5 ppm treated plants so also percent fat.

It was concluded, therefore, that the use of boron at 0·5 ppm level was most effective while its deficiency and excess showed homologous effect in some cases.

79. The effect of Boron on the germination of *Lycoporicum esculentum* seeds (var. matchless).

AMAR SINGH AND NAND RAM SINGH, *Department of Botany University of Allahabad, Allahabad.*

Germination tests were conducted under laboratory conditions to determine the response of the seed to 0·002, 0·02, 0·2, 1·0 and 2·0 ppm concentrations of boron supplied in aqueous solution. The source of boron was boric acid and soaking of the seed was done for 4 and 6 hours in two separate series.

Boron and its lower concentration of 0 002 ppm improved the germination percentage at both the duration of soaking. Soaking for six hours was more effective. Early elongation of root and shoot was increased by 0·002 ppm and 0·02 ppm concentrations. Rest of the concentrations in both the durations of soaking proved inhibitory.

The effect of boron on the control of initial phases of the life of the plant from the seed to the seedling was thus well marked and needed careful conideration in the treatment of other crop seeds by trace elements.

80. The effect of foliar spray of Boron on the growth, quality and yield of *Lycopersicum esculentum* (var. Matchless).

AMAR SINGH AND NAND RAM SINGH, *Department of Botany, University of Allahabad, Allahabad.*

Investigations were conducted under field conditions with randomised block design in order to elucidate the effect of boron in the form of boric acid on the foliage at the level of 0·5 ppm, 1·0 ppm and 2 ppm applied as foliar spray on the growth, composition, yield and storage quality of tomato.

Twenty days after the transplanting of seedlings, spraying was done with a fine atomizer. Growth observations, *viz.*, linear growth of shoot, leaf number, branch number and flower number were recorded at the interval of fortnight. The average of sixteen replicates, was taken to judge the effect of the treatments for each of the growth attributes. At the same age leaves were plucked and fractioned into petiole and leaflets and their moisture content, dry matter percentage total nitrogen, ash percentage were estimated. The rate of dry matter accumulation, reducing sugars, non-reducing sugars starch and vitamin C content in the fruits was evaluated, at weekly intervals. In order to assess keeping quality as affected by the treatment, ripened fruits were stored at 25°C and also 0°C. The produce from different observations was added to show the total yield differences as affected by the treatments.

2·0 ppm concentration proved optimum for linear growth through 1·0 ppm and 0·5 ppm were also significant in their effect. Maximum number of leaves was noted in the 2·0 ppm treatment. Significant increase was also brought about by 1·0 ppm and 0·5 ppm doses in this respect. Branching was significantly influenced by all the treatments when compared to the control.

Boron concentrations increased the moisture percentage in the leaflets but decreased that of the petiole. Dry matter on the contrary, was increased in the petiole and was decreased in the leaflets by boron. Ash percentage in the leaflets was decreased by all the boron concentrations though it increased in the petiole. 2.0 ppm boron concentration accumulated higher nitrogen (percentage) in the petiole though it invariably decreased in the leaflets.

The three levels of boron tried increased dry matter accumulation in the fruits at all stages. Both 1·0 and 2·0 ppm concentrations increased the reducing sugar percentage in the early stage of the fruit, but were ineffective later. 2·0 and 1·0 ppm concentrations increased the accumulation of non-reducing sugars in the fruits significantly at all stages. A significant increase in the starch content of fruit was influenced by boron treatments.

In the immature fruit vitamin C content was maximum in 1·0 ppm concentration, but for ripe fruits 2·0 ppm augmented the highest amount of vitamin C.

All the concentrations increased the yield per plot as well as per plant though 2·0 ppm proved optimum. Fruit number also increased significantly with application of boron specially at the maximum concentration.

The keeping quality of the fruit of the boron fed plants was lower than those of the control plants since at 25°C the fruits changed to undesirable colour and became mellow and soft.

81. The effect of frequency of irrigation on the chemical composition of *Phaseolus radiatus* and *Triticum aestivum*.

AMAR SINGH AND RAM SINGH, *Botany Department, University of Allahabad, Allahabad.*

The effect of water supply (controlled by its frequency) was studied on *Phaseolus radiatus* (moong type T_1) and *Triticum aestivum* (R_8—Vijaya an X-ray mutant of NP_{59}), under pot culture conditions. The frequency of water supply taken to represent the unit of irrigation affected the intake, retention of accumulation of various plant constituents of the two plants.

The quantity of water supply was kept the same in all cases at any particular time while the frequency of the time of application was changed. Equal amounts of 2 litres of water was applied to each pot at regular intervals of 3, 5, 7 or 9 days to form the four levels of treatments respectively.

Calculated on the basis of the total water supplied in the life of the two crops 9·54, 6·08, 4·34, and 3·47 acre-inch in the case of *Phaseolus*, and 21·69, 13·88, 9·5 and 7·81 in the case of *Triticum* was supplied. Growth observations and also soil composition were recorded at an interval of 15 days.

Calcium, nitrogen, carbohydrates and phosphorus increased in 3·47 acre-inch irrigation in *Phaseolus radiatus* while organic matter, ash, potassium and fat

contents decreased under similar conditions of restricted water supply. Fat accumulation was highest in 9·54 acre-inch, while, ash, and potassium were maximum under 6·0ᵔ acre-inches of irrigation.

13·8 acre-inch of irrigation was outstanding for tillering, leaf production and assimilatory leaf surface in wheat plant ; for the vertical growth, 21·69 acre-inch proved optimum. In reproductive phase 9·54 acre-inch increased the fresh and dry weights of the ears as well as the grains. Yield per plant was also highest, though the assimilating surface was larger under the 21·69 acre-inch of irrigation and the fresh and dry weights of the tops were still higher under 13·88 acre-inches treatment.

82. The effect of varying supply of nitrogen, phosphorus and water on the growth and yield of Solanum melongena.

Amar Singh and Mahendra Singh, Botany Department, University of Allahabad, Allahabad.

The investigations were conducted in randomised block design. Four replicates were maintained for each treatment and 30 seedlings were transplanted in each plot. At the age of 23 days, 60 lb of nitrogen in the form of sulphate of ammonium, and 120 lb of P_2O_5 as superphosphate were applied. Water was supplied at the rate of 30·0 gallons per plot in water-treated series at weekly intervals ; control plot received half this quantity.

Leaf area per plant as well as per plot increased in nitrogen, phosphorus and water treatments to diminishing degrees, this trend was exhibited throughout the life of the plant. In nitrogen series, leaf area of a single leaf was increased upto 65 day—age but it tended to decrease between 80 and 95 day-age. In phosphorus and water treatments the maximum leaf area was obtained upto 50 day—age only, there was decline at the rest of the stages. Maximum number of leaves was produced by nitrogen treatment next in order being water followed by phosphorus.

Greater produce and larger number of fruits were obtained by the phosphorus treatment followed by nitrogen and water treatment successively.

83. Physiological bearing of the process of respiration and chemical composition of certain crop plants.

Amar Singh and B. C. Bhatt, Botany Department, University of Allahabad, Allahabad.

Triticum aestivum L. (C_{19}) and Brassica campastris, were grown in field. The measurement of respiration rate and estimation of various chemical components of plant were carried out during subsequent observations.

NAR in wheat as well as Brassica, showed steady increase throughout the vegetative and flowering stage but it declined with the onset of post fertilization and grain setting stage. Respiration rate first increased to a maximum and then decreased progressively with the age of the plants.

In plants of both the genera maximum value of moisture percentage was recorded at an age of 37 days after which it declined progressively. Dry matter accumulation in the plants was directly proportional to age in the two plant genera.

Maximum sugar accumulation was found at the age of 87 days after which it sharply declined. It was found that rapid accumulation of fats coincided with reduction in sugars. Highest percentage increase in fat content was observed between 87 and 100 days. The percentage of total nitrogen was also higher than that of wheat.

It was concluded that despite generic differences between these two plants the course of respiration and chemical composition at various stages of growth generally followed a common path, showing thereby, that in nature plant metabolism was set and adjusted in similar pattern, though the intensities varied.

84. The interrelationship of the respiratory drift with chemical composition and age in *Triticum aestivum* and *Cicer arietinum*

AMAR SINGH AND S. M. A. NAQVI, *Botany Department University of Allahabad, Allahabad.*

Triticum aestivum (var C_{19}) and *Cicer arietinum* (var. T_{87}) were taken for these field investigations. The crops were grown and subsequent observations for respiration, growth and composition of plants were made. Respiration rate was measured by Blackman's apparatus and net assimilation rate by Sach's method.

The net assimilation rate was lower in the vegetative phase of the life cycle, this increased immensely with the initiation of the reproductive phase, decreasing again towards the end of the life cycle. Wheat plants showed higher NAR than gram. Maximum rate of respiration was recorded at the tillering stage in wheat and at branching stage in gram. This coincided with the 30-day age of the crops. With further advance in age the rate of the respiration decreased in both the crops.

Tissue-moisture was higher in the early stage and decreased gradually with the age upto the grain formation stage after which an abrupt, fall was noticed. Dry matter accumulation was found to increase during the life cycle but showed an insignificant decrease at end.

As compared to wheat, gram showed a higher percentage of nitrogen, phosphorus and protein. On the fresh weight basis the starchy crop, wheat, showed higher rate of respiration than the proteinaceous gram ; on dry unit weight basis, the crop with higher percentage of protein, phosphorus and nitrogen showed higher rate of respiration.

85. The effect of foliar application of hormones on growth, quality and yield of *Solanum melongena.*

AMAR SINGH AND K. INAM, *Botany Department, University of Allahabad, Allahabad.*

The effect of foliar spray of 2 ppm concentration of Indole-3-acetic acid (IAA), Indole-3-butyric acid (IBA), 2–Nepthoxy acetic acid (NAA) and Na-salt of 2, 4-dichlorophenoxyacetic acid (2, 4-D) on brinjal was investigated under field conditions of randomised block design. Four replicates were maintained for each treatment. Observations for various growth characters were made fortnightly.

The vertical growth of the plant was greatly increased by IAA treatment followed by IBA, NAA and 2, 4–D. Indole butyric acid increased the number of leaves to the maximum, while IAA and NAA followed IBA in this regard. Leaf area was considerably increased by IAA which was followed by IBA and NAA. The growth regulator 2, 4–D reduced the leaf size though the number of leaves was not affected.

The fresh weights of the leaves and the fruits were greatly increased in the plant treated with IAA, IBA and NAA as against the control. The effect of 2, 4–D in both fruits and leaves was less than the control. Dry matter accumulation in fruits and leaves was increased in IBA, IAA, NAA and 2, 4–D in decreasing degrees. IAA increased the ash content in the leaves and fruits ; IBA was better than NAA and 2, 4–D and there higher than control.

The reducing sugars of the leaves were increased in IAA followed by IBA and NAA while fruits showed higher percentage of reducing sugars in comparison to leaves. The highest value was in IAA treatment followed by IBA, NAA and 2, 4–D. Total nitrogen was higher in both leaves and fruits in the plants treated with IAA and IBA followed by NAA and 2, 4–D.

IAA and IBA treatments were found more effective in increasing the number of fruits in comparison to NAA and 2, 4–D. IAA and IBA also improved the quality of the produce.

86. A comparative study of the efficiency of different systems of storage.

AMAR SINGH AND B. S. BISHT, *Botany Department, University of Alla habad, Allahabad.*

Wheat seeds obtained from five different systems of storage of grains, *i.e.,* '*Kotha*', '*Khatti*', '*Khondia*', '*Kothi*' and '*Dholi*' were kept in closed glass bottles. Purity test, absolute weight and shrivelling percentage were determined along with germination percentage, catalase activity and vitamin B_1 content. Fungus studies were also made.

Germination percentage was best in seeds of '*Kotha*' system, followed by '*Khatti*' and '*Khondia*'. Samples of *Khatti's* system showed very high purity percentage followed by *Khondia, Kotha, Dholi* and *Kothi* in succession. *Kotha* showed least shrivelled grains followed by *Khatti, Khondia, Dholi* and *Kothi* in order.

Maximum absolute weight was recorded by samples from *Khatti* system possibly due to high water content, followed by *Kotha, Dholi,· Khondia,* and *Kothi* system. Highest catalase activity was found in samples of *Kotha* system followed by *Khatti, Khondia, Dholi* and *Kothi.* Highest vitamin B_1 was recorded in *Khatti* system followed by that in *Khondia.*

The incidence of fungus infection was significantly low in samples of *Kotha* system in comparison to *Dholi* and *Kothi.* Sample from *Kotha* system was severely infested by '*Khapra*' and '*Susri*'.

It was concluded that germination, catalase activity, shrivelling percentage and freedom from fungus infection was found to be at highest in '*Kotha*' system of storage, closely followed by '*Khatti*' and '*Khondia*' which were singnificantly superior to *Dholi* and *Kothi* systems.

87. The action of plant growth substances as selective weed killers.

AMAR SINGH AND S. K. SRIVASTAVA, *Botany Department, University of Allahabad, Allahabad.*

The effects of selective herbicidal action of hormones and fernoxone were studied on monocot and dicot weeds. The physiological and histological actions of the herbicides were noted.

Digera arvensis, Celosia argentata, Leucas aspera, Gynandropsis pentaphylla, Phyllanthus niruri, Datura fastussa, Cyperus rotundus, Crotalaria medicaginea and *Chenopodium album* were entirely killed by 2, 4-D and 2, 4, 5-T. *Commelina bengalensis, Cynodon dactylon, Amaranthus spinosus, Tribulus terrestris* and wild radish were insensitive to the hormones. Grasses of monocot type were resistant to the action of 2, 4-D.

On *Datura fastussa* and *Gynandropsis pentaphylla* 2, 4-D and 2, 4, 5-T were most effective amongst the chemicals tried. Feronoxone was found harmful for wheat. Sugars were reduced in the leaves treated with 2, 4-D. The major distortions were found in the vascular bundles by 2, 4-D and abnormal cell divisions were found in the young germinating wheat seedlings treated with 2, 4-D.

88. The effect of ultra-violet irradiation on germination, growth, chemical composition and yield of *Brassica alba* (var. T_{10}).

AMAR SINGH AND K. N. S. YADAV, *Botany Department, University of Allahabad.*

The influence of ultra-violet radiation on germination of *Brassica alba* (var. T_{10}) seeds, in the laboratory, and its subsequent growth under field conditions was studied. Ultra-violet radiation was found ineffective for increasing the germination percentage of dry as well as water soaked seeds, but early radicle and plumule elongation was recorded. Presoaked seeds were more effective than dry. At the successive stages of observation more or less all the growth attributes, *i.e.*, height, branching habit, leaf number, leaf area, flowering and fruiting behaviour, number of fruits per plant and number of seeds per pod were positively affected. Greater increase in fresh and dry weight of stem and leaf, was recorded in treated than control, except in fruit, *i.e.*, treated fruits showed lower fresh weight than control. Ash and fat percentage in root, stem, leaf and fruit was more in ultra-violet treated plants than control. Alike the growth features ultra-violet treatment brought forward appreciable increase in grain and straw yield.

89. The effect of ultra-violet treatment on the growth, composition and yield of *Cicer arietinum* (var. T_{87}).

AMAR SINGH AND VISHNU KANT, *Botany Department, University of Allahabad, Allahabad, India.*

A study of pre-sowings, utlra-violet exposure effect on the early growth of seedlings, and the subsequent growth chemical composition and yield of *Cicer arietinum* (T 87) raised under field, as well as pot conditions was made.

Studies for the growth attributes, viz., linear height, number of branches, number of leaves and in case of root, the root length and nodule number varied from the control as a result of treatment by ultra-violet radiation. Ultra-violet radiation tended to produce large number of flowers and pods over control. Ultra-violet treatment also caused an increase in the fresh weight and dry matter accumulation. The percentage of tissue moisture was found to be lower in the treated plants. Ultra-violet treatment also caused a marked increase in the ash content in the roots, tops and pods of plants raised from pre-treated seeds. The percentage of total sugars was reduced in the plants of the treated set. In the case of pods an increase in the sugar content was noticed. A marked increase in total nitrogen and protein content was observed throughout the life. The absorption of phosphorus, as a result of ultra-violet treatment, increased, and a correlation has been envisaged to exist between phosphorus content and carbohydrate fractions. Anatomical study was made of the radicles. It was noted that ultra-violet treatment caused an injurious effect on the histology of radicles. The yield of the crop which was of much importance was increased in the treated set but the effect was not significant.

90. The effect of ultra-violet irradiation on germination, growth, composition and yield of *Triticum aestivum*.

AMAR SINGH AND K. N. L. SRIVASTAVA, *Botany Department, University of Allahabad, Allahabad.*

In order to visualize the influence of ultra-violet irradiation on *Triticum aestivum*, field trial was conducted on the experimental farm in the randomized layout method. Ultra-violet irradiation, as its shorter exposures of 2 and 5 minutes improved the germination percentage and early root and shoot elongation with 6 and 24 hrs of water soaking and unsoaked seeds. Soaking for 24 hrs proved more effective. Ultra-violet irradiation for 2 minutes exposures proved optimum for increasing the linear growth, leaf number, number of internodes and tillers. Moisture percentage in stem, leaf and root was insignificantly increased through the irradiation. Dry weight, ash percentage in leaf, stem and ear were increased by the ultra-violet irradiation. Plant of the seed exposed to ultra-violet recorded maximum nitrogen and phosphorus in leaf and stem. Leaf potassium was insignificantly increased by the ultra-violet treatment, but significant increase was found in stem postash. Ultra-violet treated plants significantly increased calcium and silica content of leaf and stem. Ultra-violet irradiation decreased the accumulation of non-reducing sugar and increased the starch content in leaf and stem.

Ultra-violet irradiation increased yield of both grain and straw significantly.

91. Contribution to the ecology of *Achyranthes aspera* Linn.

A. P. SINGH, *Department of Botany, Banaras Hindu University.*

Achyranthes aspera Linn. (of family Amarantaceae) is a very common weed of Varanasi District. It is an erect, spreading annual herb, growing to a height

of 5 to 100 cm approx. with many spreading branches. The performance of plant is better in shade locality. The length of internodes, leaves and spikes are vary markedly in sun and shade. There is no close relationship between *A. aspera* and its associates. However *Cassia tora, Cynodon dactylon* and some Compositae members are its common associates. Soil analysis data clearly shows that CO_3, $^-$ NO_3^-, and exchangeable bases like Mg^{++}, Ca^{++} have no special effect on plant growth. The root and shoot ratio vary in relation to sun and shade. There is great difference in seed output of plant in shade and sunny situation. The shape index of seed as expressed by length/breadth ratio is a constent feature.

92. Some observations on the effect of burn and repair of tissue of *Lumbricus terristris*.

B. P. PANDE, *Department of Zoology C. M. College, (University of Bihar), Darbhanga.*

The lateral region of the clitellum of *Lumbricus* is burnt for a second. A red flare develop around the burnt region. The wound is partially covered by blood-clotting under the dead tissue. The clot does not dry up as in vertebrates. Gradually the scab splits off completely and the underlying debris tends to come off with the burnt tissue. The wound is infiltrated with fragments of damage longitudinal, circular muscle fibres, blood plasma, amoebocytes, and chloragogen cells. Blastema from local muscle cells, blood cells and migrating amobocyte's are found into the wound. The new epithelial cells have stretched out individu-ally from the undamaged epidermis to cover the wound by the third day. Some of the debris is trapped inside the body by the new epithelial covering and is sorrounded with chloragogen cells and amoebocytes. Adjacent to the burnt area, albumen gland cells have coagulated, the connective tissues have enlarged and the mucous glands have been destroyed by the heat. It appears that the chloragogen cells and amoebocytes are ingesting the dead tissues. The undamag-ed circular muscles have sprouted fine strands and invading the burnt area. After a week, the epithelial cells have become normal in shape. The process of demolition is still in progress in the body cavity and the dead tissue is sorrounded by the chloragogen cells and amoebocytes. The blastema of longitudinal muscle has differentiated into fine strands. By the fourteenth day, both circular and longitudinal fibres are gradually taking normal form and the parietal peritoneum is completely reformed.

The examination of the regenerate after five months, shows that glands have developed in the connective tissue layer. There are many albumen glands and a few mucous glands. They are smaller in size as compared with normal. How-ever, the growth process is very slow.

93. Studies on fungal diseases of some tropical fruits—V. Some unrecord-ed fungi.

R. N. TANDON, M. P. SRIVASTAVA, S. N. BHARGAVA AND A. K. GHOSH, *Botany Department, University of Allahabad, Allahabad, India.*

During the survey of the fungal diseases of some tropical and subtropical fruits, undertaken by the authors since 1962 a number of fungi were found associated with the various parts of the host.

The present note deals with those fungi only which are either new for the host or are unrecorded from India.

	Host/Organism	Substratum	Locality
1.	*Achras sapota* L. (Sapodilla)		
	1. *Fusarium roseum* Link	Fruit	Delhi
	2. *Phomopsis* sp.	,,	,;
2.	*Carica papaya* L. (Papaya)		
	1. *Hendersonula toruloidea* Nattras	Stem	Allahabad
	2. *Myrothecium roridum* Tode ex Fr.	Leaf	,,
	*3. *Sordaria allahabadensis* Srivastava *et al.*	Flower	,,
3.	*Litchi chinensis* Sonner (Litchi)		
	1. *Malustela aeria* Batista *et al.*	Fruit	Krishnagar
	+2. *Microascus cinereus* (Emile-Weil and Gaud.) Curzi	,,	Muzaffarpur
	+3. *Nectria haematococca* Berk. and Br. var. *breviconis* (Wr.) Booth	,,	Krishnagar
4.	*Mangifera indica* L. (Mango)		
	1. *Cochliobolus spicifer* Nelson	Fruit	Meerut
	2. *Helminthosporium hawaiiense* Bougnicourt	,,	Delhi
	3. *Macrophomina phaseoli* (Maubl.) Ashby	,,	Patna
	*4. *Phomopsis amraii* Srivastava *et al.*	Leaf	Allahabad
5.	*Musa paradisiaca* L. (Banana)		
	1. *Cochliobolus spicifer* Nelson	Peduncle	Chinsura
	2. *Macrophomina phaseoli* (Maubl.)	Leaf	Allahabad
	3. *Malustela aeria* Batista *et al.*	Fruit	Chinsura
6.	*Punica granatum* L. (Pomegranate)		
	1. *Aspergillus chevalieri* (Maug.) Thom, and Church	Flower	Jodhpur
	2. *A. flavus* Link	Fruit	Jaipur
	3. *A. repens* (Corda) Sacc.	Flower	Jodhpur
	4. *Aureobasidium* sp.	Leaf	,,
	5. *Curvularia lunata* (Wakk.) Boed	,,	,,
	6. *C. siddiquii* Ahmad and Quraishi	,,	,,
	7. *C. verruculosa* Tand. and Bil.	,,	,,
	8. *Penicillium spinulosum* Thom	Fruit	Jaipur
	9. *P. steckii* Zal.	,,	,,
	*10. *Phoma punicae* Srivastava *et al.*	Twig	Jodhpur
	+11. *Selenophoma* sp.	Fruit	Poona
	+12. *Sporodum atro-purpureum* Berk. et Cort.	Leaf	Jodhpur
	*13. *Thielavia appendiculata* Srivastava *et al.*	,,	,,

*New species described by the authors.
+New records for India.

94. Report on the occurrence of the larval form of *Taeni hydatigena* Pallas 1766 from *Capra siberica* from the Tarai forest of India.

L. N. JOHRI, *Delhi University.*

Early investigators have reported the larval forms of *Taenia hydatigena*, Pallas 1766 from India, Burma and Ceylon. Gaiger (1915) described from India, Southwell (1912, 1914) contributed from India and Ceylon, Shipley (1904) concentrated on the material mainly from Ceylon and Meggitt (1927) added the information from Burma. The present material has been procured from *Capra siberica* from the Tarai forests of India. The cysticerci were associated with the mesenteric folds and also were embedded in the thoracic muscles of the host. Two different categories of the larvae have been recognized, in one case they are covered with thick connective tissue which makes rather difficult to recognize them, while the other type bears only a thin, simitransparent covering, and it is very easy to detect them.

Detailed morphology of the cysticerci and the chemical composition of the fluid is also undertaken in the present investigation.

It is worthwhile to mention that the larval form of *Taenia hydatigena* Pallas, 1766 is collected for the first time from *Capra siberica* and establishes a new host record.

95. On the Structure and Behaviour of the Chromosomes of the Carp-louse, *Argulus Siamensis* Wilson (Branchiura : Crustacea)

D. N. VISHNOI, *Zoology Department, University Allahabad, Allahabad.*

Of the sub-class Branchiura of Crustacea no representative has been studied cytologically so far, and *Argulus siamensis* Wilson is the first carp-louse of the group presently investigated. The spermatogonial complement consists of 34 acrocentric chromosomes. These are spherular in shape and show variation in size : the smallest one looks like a little dot. In the early prophase of meiosis chromomeres are not distinct. Synizesis is weak and there is no definite 'bouquet' formation.

There are 17 bivalents on the metaphase plate of primary spermatocyte. The tetrads are round, indiscriminately intermingled and show no particular pattern of distribution. Seen in profile some of the elements are round, while others are so much stretched as to assume a bar-shaped form. Separation of the partners at first anaphase is normal reductional and synchronous ; each pole receives equal number of 17 dyads.

At second metaphase 17 univalents get arranged on the equatorial plate of the spindle in the same haphazard manner as the tetrads at first methaphase. Subsequently the dyads divide equationally and each daughter cell receives a paraphernalia of 17 monads. Throughout the course of division no sex chromosome is indentifiable.

In *Argulus siamensis* Wilson localization of chiasmata combining the terminal and centric system has not been found. Callan's (1941) hypothesis, that this kind of localization of chiasmata which limits greatly the mechanism of recombination is an adaptation towards parasitic mode of life, could not be confirmed for the carp-louse *A. siamensis.*

C. B. L. SRIVASTAVA, D.PHIL. *Department of Zoology, Allahabad University.*

The lateral-line system of the neuromasts in *Gobius striatus* is of a peculiar type with distinct modifications from the condition found in other teleosts. The lateral lines of the trunk do not exist as canals and are represented by free surface neuromasts which are situated on the epidermis of some scales bordering the dorsal edge of the opercular aperture and above the pectoral fin of their side. The cephalic-lines are greatly modified. The infraorbital and mandibular lines are superficial and consist of surface-organs and lack canals. The cheek-lines consisting of pit-organs are present along many superficial horizontal lines. The supraorbital and preopercular lines have only short canal portions and for the most part of their length are superficial. The preopercular line does not reach the temporal line of its side. The supraorbital lines of the two sides are closely approximated at their middle parts in the narrow interorbital region. Variations occurs from individual to individual and on the two sides of the same individual in respect to the number and nature of the spores by which the canals pen to the exterior.

98. Structure and Behaviour of the Chromosomes of *Fasciola gigantica* Cobbold, 1856. (Trematoda ; Digenea : Fasciolidae).

oM. D. L. SRIVASTAVA AND A. G, JHA, *Department of Zoology, University of Allahabad, Allahabad.*

Much work has been done on the spermatogenesis and oogenesis of *Fasciola hepatica* Linnaeus but no attention has been paid to the karyotype of *Fasciola gigantica*, which is allied to the former species and is abundantly available in India from the liver of buffalo. The present paper reports the structure and behaviour of chromosomes in this worm.

The diploid number, as counted on the spermatogonial metaphase plate, is 16 : which is in confirmity with the presence of 8 bivalents at the first metaphase and 8 dyads at the second metaphase. The chromosomes are quite big in size and there is a good deal of difference in the sizes of the different chromosomes. The two pairs of chromosomes which are the biggest are metacentric, the rest appear to be acrocentric.

The leptotene threads are found spread inside the entire nuclear space ; they carry a number of chromomeres. No polarisation is noticed. The zygotene pairing is distinctly observed. At diplotene, all the chromosomes show chiasma-formation, the maximum number of chiasmata for any bivalent is 3, which is found in the two largest bivalents. At diakinesis, the bivalents possess a characteristic lobed structure.

At the first anaphase a chromosomal bridge has been noticed in several spermatocytes, and in one of them an acentric fragment is also present indicating crossing over in an inverted segment.

99. Structure and Behaviour of the chromosomes of *Paramphistomum crassum* **Stiles and Goldberger (Trematoda : Digenea : Paramphistomidae).**

M. D. L. SRIVASTAVA AND A. G. JHA, *Department of Zoology, University of Allahabad, Allahabad.*

The diploid number of chromosomes is 14, as ascertained at spermatogonial mataphase. In this species also the size gradations of the chromosomes are distinct ; one is large. two are small and four are of medium size which are not easily distinguished from each other. The maximum number of chiasmata for any single bivalent is 3 which is found in the largest bivalent and one belonging to the medium category.

At the first metaphase (side view), the bivalents are dumb-bell shaped, and all 7 of them are distinctly observable.

100. Structure and Behaviour of the Chromosomes of *Isoparorchis hypselobagri* **Billet, 1898. (Trematoda : Digenea : Hemiuridae).**

M. D. L. SRIVASTAVA AND A. G. JHA, *Department of Zoology, University of Allahabad, Allahabad.*

The diploid karyotype consists of eighteen chromosomes as observed at the spermatogonial metaphase.

In meiosis, polarisation of chromosome threads is a prominent feature of leptotene, zygotene and pachytene stages. At diplotene, the largest bivalent may bear as many as 4 chiasmata. At diakinesis the bivalents appear irregular. The chromosomes are of unequal sizes and are all acrocentric.

Cytological work on this species has been done by Dhingra. His *Isoparorchis eurytremum* is synonymous with *I. hypselobagri* studied by us. But the diploid chromosome number according to him is 20, whereas we find only eighteen.

APPENDIX I

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LIST OF JOURNALS ON EXCHANGE LIST

FOREIGN

1. Abhandlungen der Deutscen Akademic der Wissenschafte zu Berlin (Berlin, Germany)
2. Acta Biologica Cracoviensia : Botanica (Slawkowske, Poland)
3. Acta Biologica Cracoviensia : Zoologica (Slawkowske, Poland)
4. Acta Biologica Venezuelica (Cracas, Venezuela)
5. Acta Hydrobiologica (Karkow, Poland)
6. Acta Physica Polonica (Warsaw, Poland)
7. American Journal of Science (New Haven, Connecticut, U. S. A.)
8. Anias da Academia Brasil eria de Ciencias (Rio De Janeiro, Brazil)
9 Annual Report of Scientific Works, Faculty of Science, Osaka University (Osaka, Japan).
10. Archives des Sciences (Geneva, Switzerland)
11. Archiwum Electrotechniki (Warsaw, Poland)
12. Agrokemia Es Talajtan (Budapest, Yugoslavia)
13. Archives de Mecanique Appliquee (Warszawa, Poland)
14. Analele Universitatii din Timisoara (Timisoara, Rumania)
15. Annuary of the Bucharest Observatory (Eucuresti, Rumania)
16. Biochemical Journal (London, England)
17. Biologiske Meddelesar (Copenhagen, Denmark)
18. Biologiske Skrifter det Konglige Videskabernes Selskab (Copenhagen, Denmark)
19. Breviora (Cambridge, Mass, U. S. A.)
20. Bulletin de I'Academie Polonoise des Sciences, (Warsaw, Poland)
21. Bulletin of the Institute for the study of the USSR (Munich, Germany)
22. Bulletin of the Institute for Chemical Research, (Kyoto, Japan)
23. Bulletinul Institution Politechnic Bucaresti (Grivitat, Romania)
24. Bulletinul Institution Politechnic din Issi (Lasi R. R., Romania)
25. The Bell System Technical Journal (New York, U. S. A.)
26. Biological Bulletin (Laneaster, U. S. A.)
27. Canadian Journal of Biochemistry (Ottawa, Canada)
28. Canadian Journal of Botany (Ottawa, Canada)
29. Canadian Journal of Chemistry (Ottawa, Canada)
30. Canadian Journal of Physics (Ottawa, Canada)
31. Canadian Journal of Zoology (Ottawa, Canada)
32. Comision Nacional De Energia Nuclear (Mexico)
33. Communications from the Kamerlingh Onnes Laboratory of University of Leiden (Leiden, Netherland)
34. Current Chemical Papers (London, England)
35. Endeavour (London, England)
36. Folia Biologica (Krakow, Poland)
37. German Research Service (Bad Godes berg, Germany)
38. Helminthological Abstracts (Bucks, England)
39. Izvestiya Academy Sciences (U. S. S. R.)

40. Japanese Journal of Mathematics (Tokyo, Japan)
41. Journal and Proceedings of the Royal Society of New South Wales, (Sydney, Australia)
42. Journal of the Faculty of Science, Hokaido University (Sappora, Japan)
43. Journal of the Faculty of Science, University of Tokyo (Tokyo, Japan)
44. Journal of the Institute of Polytechnic (Osaka, Japan)
45. Journal of the Physical Society of Japan (Tokyo, Japan)
46. Journals of Mathematics and Physics (Cambridge, Mass, U. S. A.)
47. Journal of the Science of Soil and Manure (Tokyo, Japan)
48. Kansas University Bulletin (Lawrence, Kan, U. S. A.)
49. Klucze do Oznaczania Owadow Polski (Warszawa, Poland)
50. Kungl Fysiografiska Sallskapets i Lund Handlinger (Lund, Sweden)
51. Mathematisk-Fysiski Meddelelser (Copenhagen, Denmark)
52. Mathematisk-Fysiski Skrifter (Copenhagen, Denmark)
53. Memoirs do Instituto Oswaldo Cruz (Rio de Janeiro, Brazil)
54. Mathematics-Fizica (Timisorara, Rumania)
55. Nagoya Mathematical Journal (Nagoya, Japan)
56. New Zealand Journal of Agricultural Research (Wellington, New Zealand)
57. New Zealand Journal of Geophysica and Geology (Wellington, New Zealand)
58. New Zealand Journal of Science (Wellington, New Zealand)
59. Nova Acta Leopoldina (Zu Halle, Germany)
60. Navitates (New York, U. S. A.)
61. Osaka Mathematical Journal (Osaka, Japan)
62. Plant Breeding Abstracts (Bucks, England)
63. Polskie Pismo Entomologiczene (Warsaw, Poland)
64. Proceedings of Cambridge Philosophical Society (Cambridge, England)
65. Proceedings of the American Philosophical Society (Philadelphia, U. S. A.)
66. Proceedings of National Academy of Sciences (Washington, U. S. A.)
67. Proceedings of the Japan Academy (Tokyo, Japan)
68. Proceedings of the Royal Society of Victoria (Melbourne, Australia)
69. Proceedings of the Royal Society of Edinburgh: Section A and B (Edinburgh, Scotland)
70. Philippine Journal of Sciences (Manila, Philippine)
71. Polska Bibliografia Analityczna Mechanik (Wiloza, Poland)
72. Pyton (Argentaina)
73. Report of the Government Chemical Industrial Research Institute (Tokyo, Japan)
74. Review of Physical Chemistry of Japan (Kyoto, Japan)
75. Review of Polish Academy of Sciences (Warsaw, Poland)
76. Scientific American (New York, U. S. A.)
77. Scientific Papers of the Institute of Physical and Chemical Research (Tokyo, Japan)
78. Sitzung Berichte der Deutscher Academi der Wissenschafter zu berlin (Berlin, Germany)
79. Soil Science and Plant Nutrition (Tokyo, Japan)
80. Transactions and Proceedings of the Royal Society of New Zealand (Wellington, New Zealand)
81. Universitas (Stuttgart, West Germany)
82. World Meterological Organisation (Geneva, Switzerland)

1. Bibliography of Scientific Publications of Scientific South East Asia (New Delhi)
2. Current Science (Bangalore)
3. Defence Science Journal (New Delhi)
4. Ganita (Lucknow)
5. Half-yearly Journal of Mysore University (Mysore)
6. Indian Journal of Agricultural Science (New Delhi)
7. Indian Journal of Chemistry (New Delhi)
8. Indian Journal of Experimental Biology (New Delhi)
9. Indian Journal of Meteorology and Geophysics (Delhi)
10. Indian Journal of Physics (Calcutta)
11. Indian Journal of Pure and Applied Physics (New Delhi)
12. Indian Journal of Technology (New Delhi)
13. Indian Journal of Veterinary Science and Animal Husbandry (New Delhi)
14. Indian Minerals (Calcutta)
15. Journal of Indian Chemical Society (Calcutta)
16. Journal of Indian Institute of Sciences (Bangalore)
17. Journal of Scientific and Industrial Research (New Delhi)
18. Proceedings of the Indian Academy of Sciences, Section A and B (Bangalore)
19. Research Bulletin of Punjab Univertity (Chandigarh)
20. UNESCO Chronicle (New Delhi)
21. Proceedings of National Institute Sciences of India, Section A and B (New Delhi)
22. Vijnana Parishad Anusandhan Patrika (Allahabad)

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Achari, G., M.B.B.S. (Hons.), Ph.D., Professor and Head of the University Department of Pharmacology, P. W. Medical College, Patna.

Agarwal, A. K., M.Sc., Ph.D., Lecturer in Chemistry, M. M. M. Engineering College, Gorakhpur.

Agarwal, G. P., M.Sc., D.Phil., Lecturer in Botany, Government Science College, Jabalpur.

†Agarwal, Ved Prakash, M.Sc., Ph.D., Professor and Head of the Zoology Dept., D. A. V. College, Muzaffarnagar.

Agarwal, Vinod (Miss), M.Sc., Research Scholar in Zoology, University of Lucknow, Lucknow.

Ahmad, Z. U., M.Sc., Senior Research Assistant, Section of the Plant Pathologist to the Government, U. P., Kanpur.

†Ahuja, Bhopindra Singh, M.Sc., Botanist, Survey of Medical Plants, Government of India Project, P. O. Gurukula Kangri (Dt. Saharanpur).

Agnihotri, Virendra Prasad, M.Sc., c/o Agnihotri Engineering Works, Rudrapur, Naini Tal.

Ambasht, J. P., M.Sc., F.R.A.S., Head of the Mathematics Department, S. P. Jain's College, Sasaram (Dt. Shahabad) Bihar.

Ambasht, R. S., M.Sc., Lecturer in Botany, Banaras Hindu University, Varanasi-5.

†Arora, R. K., M.Sc.(Hons.), Ph.D., Assistant Ecologist, Botanical Survey of India, 76 Lower Circular Road, Calcutta-14.

†Awasthi, P. N., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Saugar, Sagar.

Bagalkoti, D. R., M.Sc., Ph.D., Head of the Physics Dept., Karnatak Regional Engineering College, Surathkal, S. K.

Bagchi, A. K., B.A. (Hons.) 'Amarapati', Indian Statistical Institute, 204 Barrackpore Trunk Road, Calcutta-35.

*Bagchi, H. D., M.A., Ph.D., Peary Mohan Sur Lane, Goabagan, P. O. Beadon Street, Calcutta-6.

†Bahadur, K., M.Sc., D.Phil., D.Sc., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

Ballabh, Ram, M.Sc., Ph.D., Professor and Head of the Department of Mathematics, University of Lucknow, Lucknow,

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*Banerjee, D. P., M.A., D.Sc., F.S.S., Professor and Head of the Depart-
ment of Mathematics, Sri Venkateswara University, Tirupati (A..P.).

*†Banerjee, K., D.Sc., F.N.I., F.I.A.S., Director, Indian Association for the
Cultivation of Science, Jadavpur, Calcutta-32.

*†Banerji, A. C., M.A., M.Sc., F.R.A.S. F.N.I., I.E.S. (Retd.), Gyan Kutir,
4A Beli Road, Allahabad-2.

†Banerji, N. K., M.Sc., D.Phil., 26/13, Patkapur, Kanpur.

*Banerji, S. K., D.Sc., F.A.Sc., M.A.E.S.I., Hon.F.R.Met.Soc., 3 Ramani
Chatterjee Road, P. O. Rashbehari Avenue, Calcutta-29.

*†Banerji, S. K., M.Sc., D.Phil., Reader-Head, Chemistry Department, Birla
Institute of Technology and Science, Pilani (Rajasthan).

*Banerji, S. N., M.Sc., D.Phil., Reader in Chemistry, University of Saugar,
Sagar.

Basu Chaudhary, K. C., M.Sc., Ph.D., c/o Dr. T. C. Basu Chaudhary,
Prosadpur House, Nagar Kanti, Agra-2.

*†Basu, S., M.Sc., F.N.I., Retired Director General of Observatories, L-25
Hauz Khas Enclave, New Delhi-16.

†Baugh, S. C., M.Sc., Ph.D., Assistant Professor of Zoology, University of
Lucknow, Lucknow.

*Behari, Ram, M.A., Ph.D., Sc.D., F.N.I., F.A.Sc., Vice-Chancellor, University
of Jodhpur, Jodhpur.

Bhagwat, W. V., D.Sc., Principal and Professor of Chemistry, Vikram
University, Ujjain.

†Bhanot, V. B., M.Sc., Ph.D., Reader in Physics, Punjab University, Chandi-
garh-3.

Bharadwaj, O. N., M.Sc., Lecturer in Zoology, Holkar Science College,
Indore (M.P.).

Bhardwaj, S. N., M.Sc., Ph.D., F.B.S., Asst. Plant Physiologist, Division of
Botany, Indian Agricultural Research Institute, New Delhi-12.

†*Bhargava, H. R., M.Sc., F. B. S., Assistant Professor of Botany, University of
Saugar, Sagar.

*Bhargava, K. S., M.Sc., D.Phil., Ph.D., Professor and Head of the Botany
Department, University of Gorakhpur, Gorakhpur.

†Bhargava, S. N., M.Sc., D.Phil., Botany Department, University of Allah-
abad, Allahabad.

· Bhatia, Prem Kumar, M.Sc., Ph.D., Lecturer in Mathematics, University of
Jodhpur, Jodhpur.

Bhatia, B. B., B.V.Sc.&A.H., M.V.Sc., Research Officer (Parasitology),·
U. P. College of Veterinary Science and Animal Husbandry, Mathura.

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Dehra Dun.

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*†Bhattacharya, A. K., D.Sc., F.R.I.C., Professor and Head of the Department of Chemistry, University of Saugar, Sagar.

*†Bhattacharya, Abani K., D.Sc., F.R.I.C., Professor and Head of the Post-Graduate Department of Chemistry, J. and K. University, Jammu (Kashmir).

Bhattacharya, A. P., M.A., Research Officer, Basic Research Division, Irrigation Research Institute, Roorkee.

Bhattacharya, Arun K., M.Sc., Ph.D., Asst. Professor of Chemistry, University of Saugar, Sagar.

Bhattacharya, P. K., M.Sc., Ph.D., Lecturer ·in Chemistry, Vikram University, Ujjain.

*†Bhawalkar, D. R., M.Sc. Ph.D., Professor and Head of the Department of Physics, University of Saugar, Sagar.

Bhise, Vinayak Madhav, M.Sc., Lecturer in Mathematics, Govindram Seksaria Technological Institute, Opp. Nehru Park, Indore.

Bhonsle, B. R., M.Sc., Ph.D., Professor of ·Mathematics, Govt. Engineering College, Jabalpur.

*Bilgrami, K. S., M.Sc., D.Phil., D.Sc., Reader in Botany, University of Jodhpur, Jodhpur.

*†Biswas, B., M.Sc., Maewal Compound, Nawabganj, Kanpur.

*†Bose, K. C., M.Sc., D.Phil., Professor and Head of the Department of Zoology, Ranchi University, P. Box. No. 11, Ranchi.

*Bose, Sameer, M.Sc., Ph.D., 310 Napier Town, near Christian High School, Jabalpur.

*†Chakravarti, B., M.Sc., D.Phil., Agfa Photopaper Co., Mulund, Bombay-80.

*†Chakravarti, S. C., M.Sc., Ph.D., Principal, Government Degree College, Mhow (M. P.).

†Chakravarty, D. N., M.Sc., D.Phil., National Carbon Company, 5 Rustomji Parsee Road, Calcutta-2.

Chandra, Jagdish, M.A., Department of Mathematics, Mason Labs., Rensselaer Polytechnic Institute, Troy, N. Y. (U.S.A.).

Chandra, Sudhir, M.Sc. D.Phil., Department of Botany, University of Allahabad, Allahabad.

Chandra, Sudish, M.Sc., Research Scholar, Chemistry Department, University of Lucknow, Lucknow.

*†Chatterjee, A. C., D.Sc., Dr.Ing., c/o Department of Chemistry, University of Lucknow, Lucknow.

Chatterjee, Peetendu, M.Sc., Asst., Manager, Durrung Tea Estate—Modopee Division, P. O. Bindukuri, Dt. Darrang (Assam).

Chatterji, P. C., M.Sc., Geologist, Central Arid Zone Research Institute, Jodhpur.

†Chatterji, P. N., M.Sc., D.Phil., Department of Zoology, G. M. College, Sambalpur (Orissa).

*†Chatterji, R. G., M.Sc., D.Phil., Department of Physics, Indian Institute of Technology, Kharagpur.

*†Chatterji, U. N., D.Phil., D.Sc., F.R.S.A., Professor and Head of the Botany Department, University of Jodhpur, Jodhpur.

*†Chauhan, B. S., Ph.D., D.Sc., C.H.Z.S., F.A.Sc., F.Z.S.I., Superintending Zoologist, Zoological Survey of India, 34 Chittaranjan Avenue Calcutta-12.

Chauhan, R. N. Singh, M.Sc., D Phil. Asst. Professor of Chemistry, Th. D. S. B. Government College, Naini Tal.

Chauhan, Suresh Kumar, M.Sc., Ph.D., School of Studies in Botany, Vikram University, Ujjain.

Chhabra, S. P., M.Sc., Lecturer in Mathematics, Government Engineering College, Koni, Bilaspur.

*Chinoy, J. J., M.Sc., Ph.D., D.I.C., Head of the Department of Botany, Gujarat University, Ahmedabad.

†Chitray, Brij Behari, M.Sc., Head of the Biology Dept., H. S. J. S. College, Kanpur.

*†Chopra, Col. Sir R. N., C. I. E., M.D., Sc.D., F.R.C.P., Director, Regional Research Laboratory, Jammu and Kashmir, Canal Road, Jammu-Tawi, Kashmir.

Chopra, R. S., M.Sc., Reader in Botany, Panjab University, Amritsar.

*Choudhari, R. S., M.Sc., Ph.D., D.Sc., Reader in Agricultural Botany and Physiologist, College of Agriculture, Banaras Hindu University, Varanasi-5.

*†Chowdhary, H. S., M.Sc., D.Phil., Professor and Head of the Department of Zoology, University of Gorakhpur, Gorakhpur.

Choudhuri, D. K. M.Sc., Ph.D., D.I.C , P-14/167, Kalyani, P. O. Kalyani (W. B.).

Choudhry, R. K., Ph.D., Reader in Mathematics, L. S. College, Muzaffarpur.

Chowdhury, S. R., M.Sc., Lecturer in Botany, Government College of Science, Raipur (M. P.).

*†Chowdhury, K. A., B.A., B.Sc., M.S., D.Sc., F.N.I, Professor and Head of the Botany Department, Muslim University, Aligarh.

Dalela, G. G., M.Sc., Ph.D., Junior Specialist, Plant Pathology Section, Department of Agriculture, Rajasthan, Udaipur.

Das, Niranjan, M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad.

*†Das, S. M., D.Sc., F.Z.S., F.A.Z., F.Z.S.I., Professor of Zoology, Jammu and Kashmir University, Srinagar, Kashmir.

*†Das Gupta, S. N., Ph.D., D.Sc., D.I.C., F.N.I., Vice-Chancellor, University of Kalyani, 1B Judge's Court Road, Calcutta-27.

Das Varma, R., M.Sc., Reader in Mathematics, University of Bihar, Muzaffarpur.

*†Dave, J. S., M.Sc., Ph.D., A.R.I.C., Reader in Physical and Inorganic Chemistry, Faculty of Science, M. S. University, B aroda.

David, A., B.Sc., D.Sc., Tank Elocustine Unit of the Central Inland Fisheries Research Institute, Tungabhadra Dam (M ysore State).

Davis, T. A., B.A., P.G. Dip. (Crop Bot.), Professor of Crop Science, Indian Statistical Institute, Calcutta-35.

*Dayal, Bisheshwar, D.Sc., F.Inst. P., A.I.I.Sc., Reader in Physics, Banaras Hindu University, Varanasi-5.

Dayal, Ram, M.Sc., D.Phil., Department Pathology, College of Agriculture, Banaras Hindu University, Varanasi-5.

†Dehadrai, P. V., M.Sc., F.G.S., F.G.M.S., M M.G.I., Senior Petrologist, Oil and Natural Gas Commission, Government of India, 19 Rajpur Road, Dehra Dun

†De, Samarenda Kumar, B.Sc.Ag., M.Sc. (Ag. Bot.), M.Sc. (Ag. Chem.), D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

*†Deodhar, D. B., M.Sc., Ph.D., Anand Niwas, Havelock Road, Lucknow.

*†Dey, A. K., B.Sc. (Hons.), M.Sc., D.Phil., D.Sc., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

*†Dey, P. K., M.Sc., I.Ag.S. (Retd.), 53/1 Southern Avenue, Calcutta-29.

†Dhar, A. K., M.Sc., Assistant Agricultural Officer, Ramnugger Cane and Sugar Co., Ltd., Plassey, District Nadia (W. B.).

*Dhar, M. L., M.Sc., Ph.D., F.R.I.C., F.N.I., Director, Central Drug Research Institute, Chattar Manzil Palace, Lucknow.

*†Dhar, N. R., D.Sc., F.R.I.C., F. N. I., I.E.S. (Retd.), *Associate Member of the French Academy of Agriculture* and *Corresponding Member of the French Academy of Sciences*, Director, Sheila Dhar Institute of Soil Science, University of Allahabad, 2 D-Beli Road, Allahabad-2.

*†Dhawan, C. L., M.Sc., Ph.D., Deputy Director, Land Reclamation Irriga tion and Power Research Institute, Amritsar.

*†Doosaj, S. S., M.Sc., Principal, Govt. College, Satna (M. P.).

†Dugar, S. M., M.Sc., Research Scholar, Department of Chemistry, University of Rajasthan, Jaipur.

*†Dutta, S. K., D.Sc., 57 Tarakutir Road, Lukerganj, Allahabad.

Dwivedi, M. P., M.Sc., Asst. Professor of Zoology, Government Degree College, Chhindwara (M. P.).

Dwivedi, R. S., M.Sc., Ph.D., Lecturer in Botany, Banaras Hindu University, Varanasi-5.

Gandhi, J. N., M.Sc., Reader and Head of the Physics Department, Maharani's College, Jaipur.

†Garg, N. K., M.Sc., D.Phil, Ph.D., Division of Biochemistry, Central Drug Research Institute, Lucknow.

*†Gayre of Gayre and Nigg, Lt. Col. Robert, K.C.N., K.C.M.M., K.C.L., G.C.L.J., M.A., D.Phil, D.Pol.Sc., D.Sc., F.I.A.L., 1 Darnaway Street, Edinburgh-3 (Scotland).

†Ghadially, P. F., F.R.G.S., F.R.S.A., F.B.H.I., B.Sc., M.M.E.A., A.M.I.E., M.I.S.D., Messrs. Precists (India) Private Ltd., 43 Queen's Road, Bombay-2.

Ghoshal, Satish Chandra, B.A., B.Sc., LL.B., Retired Director of Education, Indore and Alwar States, 8 Vikramaditya Marg, Lucknow.

*†Ghosh, S., D.Sc., F.N.I., Professor and Head of the Department of Chemistry, University of Jabalpur, Jabalpur.

*†Ghosh, S. C., M.Sc., D.Phil., Assistant Professor of Zoology, University of Allahabad, Allahabad.

*†Ghosh, S. K., M.Sc., D.Phil., Assistant Agricultural Chemist to the Government of West Bengal, State Agricultural Research Institute, 230 Netaji Subhas Road, Tollygunge, Calcutta-40.

*†Ghosh, S. N., D.Sc., Professor of Applied Physics, J. K. Institute of Applied Physics, University of Allahabad, Allahabad.

*†Gill, P. S., M.S., Ph.D., M.A.P.S., F.N.I., Director, Central Scientific Instruments Organization, Chandigarh.

Gokhroo, D. C., M.Sc., c/o Dr. C. B. Rathie, Head of the Mathematics Department, M. R. Engineering College, Jaipur.

Goyal, A. N., M.Sc., Ph.D., F.R.A.S., Lecturer in Mathematics, Maharaja's College, Jaipur.

Goyal, G. K., M.Sc., Lecturer in Mathematics, University of Rajasthan, Jaipur.

†Grover, (Miss) Prabha, M.Sc., D.Phil., 14 Park Road, Allahabad-2.

Gulati, S. P., M.A., D. I. I. T., Department of Mathematics, Indian Institute of Technology, Kanpur.

†Gupta, A. B., M.Sc., Ph.D., Head of the Botany Department, Christ Church College, Kanpur.

*†Gupta, A. C., B.Sc., F.H.B.T.I., F.R.I.C., Professor of Oil and Allied Technology, Harcourt Butler Technological Institute, Kanpur.

Gupta, D. P., M.Sc., Research Scholar in Zoology, University of Sugar, Sagar

Gupta, D. R., M.Sc., Ph.D., Reader in Chemistry, University of Roorkee, Roorkee.

Gupta, K. C., M.Sc., Lecturer in Mathematics, M. R. Engineering College, Jaipur.

†Gupta, Munendra Nath, M.Sc., Ph.D., F.B.S., Associate Professor of Botany, Agra College, Agra.

Gupta, R., M.Sc., Department of Zoology, Kanya Kubja College, Lucknow.

Gupta, R. B., M.Sc., Lecturer in Zoology, M. S. College, Motihari (Champaran) Bihar.

Gupta, R. K., M.Sc., Ph.D., Dr.-es-Sciences, Section of Systematic Botany and Ecology, Central Arid Zone Research Institute., Jodhpur.

Gupta, R. P., M.Sc., Ph.D., Professor of Mathematics, D. S. B. Government College, Nainital.

Gupta, R. S., M.Sc., Officiating Reader in Mathematics, University of Allahabad, Allahabad.

†Gupta, S. C., M.Sc., Ph.D., D.I.C., F.B.S., Professor and Head of the Botany Dept., K. N. Govt. Degree College, Gyanpur (Dt. Varanasi).

Gupta, S. L., B.Sc. (Hons.), M.Sc., Lecturer in Mathematics, Faculty of Engineering, University of Jodhpur, Jodhpur.

Gupta, Y. K., M.Sc., D.Phil., Reader in Chemistry, University of Rajasthan, Jaipur.

*†Gyani, B. P., M.Sc., Ph.D., Principal, Ranchi College, Ranchi.

Gyanvati, D.Phil., Junior Scientific Officer, Defence Research Laboratory (Stores), Kanpur.

*Handa, K. L., M.Sc., F.R.I.C., F.I.C., Senior Scientific Officer, Regional Research Laboratory, Jammu (Kashmir).

Hariharan, T. A., M.Sc., Ph.D., Lecturer in Physics, Karnataka Regional Engineering College, Surathkal P. O. (S. K.), Mysore State.

Harit, Sudhanshu, M.Sc., Lecturer in Mathematics, G. R. C. College, Fatehpur (Raj.).

Hasija, S. K., M.Sc., Lecturer in Botany, Govt. Science College, 457 Napier Town, Howbagh, Jabalpur.

Indrasena, A., M.Sc., Research Scholar in Mathematics, Osmania University, Hyderabad. (A. P.).

Jain, K. D., M.Sc., Ph.D., A.R.I.C., Professor and Head of the Chemistry Department, D. A. V. College, Dehra Dun.

Jain, M. K., M.Sc., Lecturer, Chemistry Department, D. A. V. College, Dehra Dun.

Jain, R. N., B.A. (Hons.), M.A., Asst. Professor of Mathematic, Holkar Science College, Indore.

*†Jain, S. K., M.Sc., Ph.D., F.B.S., Botanical Survey of India, P. O. Indian Botanical Gardens, Calcutta.

†Jain, S. L., M.Sc., Ph.D., Geological Studies Unit, Indian Statistical Research Institute, 203 Barrackpore Trunk Road, Calcutta-35.

Jaitley, (Miss) Priyamvada, M.Sc., D.Phil., Lecturer in Zoology, Govt. Hamidia College, Bhopal.

Jha, D. K., M.A., B.L., Ph.D., Lecturer in Mathematics, L. S. College, Muzzaffarpur.

Jha, S. N., B.Sc. (Hons.), M.Sc., Lecturer in Mathematics, L. S. College, Muzaffarpur.

*Jhingran, A. G., M.Sc., Ph.D., F.N.I., F. G.M.S., M.M.G.I., Director, Eastern Region, Geological Survey of India, 5 Middleton Street, Calcutta-13.

Johri, L. N., D.Sc., Reader in Zoology, University of Delhi, Delhi-7.

*Joshi, A. C., D.Sc., F.N.I., Vice-Chancellor, Panjab University, Chandigarh-3.

Joshi, N. C., M.Sc., Ph.D., F.B.S., Asst. Systematic Mycologist, Directorate of Plant Protection, 4/19 Ajmeri Gate Extension, New Delhi.

Kahate, Sindhu, M.Sc., Lecturer in Botany, Kamla Nehru Hall for Woman, University of Jodhpur, Jodhpur.

Kamala, P. S. (Miss), M.Sc., Research Scholar in Mathematics, Osmania University, Hyderabad.

*†Kapoor, R. C., M.Sc., D.Phil. D.Sc., Professor and Head of the Department of Chemistry, University of Jodhpur, Jodhpur.

Kapur, J. N., M.A., Ph.D., Professor and Head of the Mathematics Department, Indian Institute of Technology, Kanpur.

*Kar, B. K., Ph.D., F. B. S., Head of the Botany Department, Viswa-Bharati, Santiniketan.

Kaul, V., M.Sc., Ph.D., Head ·of the Post-graduate Department of Botany, J. and K. University, Amar Singh Bagh, Srinagar, Kashmir.

Kaushic, S. D., M.A., Ph.D., Professor and Head of the Geography Department, S. S. V. College, Hapur.

†Khan, Reayat, M.Sc. Ph.D., Department of ‡Botany, Aligarh Muslim University, Aligarh.

Khandekar, P. R., M.A., Professor of Mathematics, M. V. Mahavidyalaya, Bhopal.

Khare, R. C., M.A., D.Phil., Lecturer in Mathematics, University of Allahabad, Allahabad.

Konar, S. K., M.Sc., Lecturer in Zoology, L. S. College, Muzaffarpur.

†Kothari, Hemraj, B.Sc., D.W.P., A.C.C.G.I., A.M.S.E., F.C.I., F.B.I.S., I.M.I., Conslt. E., A.M.A.I.M., Management and Technical Consultant and Chief Executive, Kothari Consultants, 12 India Exchange Place, Calcutta-1.

Koul, M. L. Hakoo, M.Sc., Research Scholar in Botany, Banaras Hindu University, Varanasi-5.

*†Krishna, Bal, M.Sc., D.Phil., Assistant Professor of Chemistry, Univerity of Allahabad, Allahabad,

Krishna, Daya, M.Sc., D.Phil., Professor and Head of the Department of Zoology, Govt. College, Ajmer.

Krishnaji, M.Sc., Officiating Reader, Physics Department, University of Allahabad, Allahabad.

Krishnamurthy, K. N., B. Sc. (Hons.), Research Assistant, Central Inland Fisheries Research Institute, P. O. Tungabhadra Dam, Dt. Bellary, Mysore State.

Kulshreshtha, S. K., M.Sc.. Research Scholar in Mathematics, University of Rajasthan, Jaipur.

†Kumar, Ram, M Sc., Ph.D., D.Sc., Professor of Mathematics and Head of the Department of Applied Mathematics, Applied Science and Humanities, M. L N. Regional Engineering College, Allahabad.

*†Kushwaha, R. S., M.Sc., D.Phil., Ph.D., Professor and Head of the Department of Mathematics, University of Jodhpur, Jodhpur.

*†Lakhanpal, R. N., M.Sc., Ph.D., F.B.S., Assistant Director, Birbal Sahni Institute of Palaeobotany, University Road, Lucknow.

†Lakshmikanth, V., M.A., Professor of Mathematics, Marathawada University Aurangabad.

†Lahshminarayana, G., M.A., Ph.D., Asst. Professor of Mathematics, Regional Engineering College, Warangal (A. P.).

Lakshminarayana, K. V., M.Sc., Asst. Zoologist, Zoological Survey of India, 34 Chittaranjan Avenue, Calcutta-12.

Lal, Bal Krishna, M.Sc., Lecturer in Mathematics, L. S. College, Muzaffarpur.

*Lal, J. B., D.Sc., B. S. E.(Chem.Engg.), M.S.E., F.I.C., M.I.Chem.E., Head of the Chemical Engineering Section and Industrial Chemist to the U. P. Government, H. B. Technological Institute, Kanpur.

Lal, Krishna, M.Sc., D.Phil., Lecturer in Engineering Mathemtics, Engineering College, Banaras Hindu University, Varanasi-5.

Lal, K. B., M.A., Ph.D., Assistant Professor of Mathematics, University of Gorakhpur, Gorakhpur.

Lal, M. B., M.Sc., Ph.D., M.A., LL.B., Head of the Zoology Dept., D. A. V. College, Dehra Dun.

Lall, S. B., M.Sc., Ph.D., Lecturer in Botany, College of Agriculture, Nagpur.

Loiwal, S. D., M.Sc., D.Phil., Asst. Professor of Chemistry, Birla College, Pilani (Rajasthan).

*†Mahabale, T. S., B.A., M.Sc., Ph.D., F.N.I., F.A.Sc., F.B.S., Head of the Department of Botany, University of Poona, Ganeshkhind, Poona-7.

†Mahajani, A. V., M.Sc., Ph.D., Assistant Professor of Chemistry, University of Saugar, Sagar.

*Mahalanobis, P. C., M.A., I.E.S. (Retd.), F.R.S., F.N.I., Director, Indian Statistical Research Institute, 204 Barrackpore Trunk Road, Calcutta-35.

*Maheshwari, P., D.Sc., F.R.S., F.N.I., F.B.S., F.A.Sc., Professor and Head of the Botany Department, University of Delhi, Delhi-7.

*†Majumdar, K., D.Sc., 20 Minto Road, Allahabad-2

Majupuria, T. C., M.Sc., Ph.D., Head of the Zoology Department, M. S. (Post-graduate) College, Saharanpur.

*Malik, W. U., M.Sc., Ph.D., D.Sc., Professor and Head of the Chemistry Department, University of Roorkee, Roorkee.

Mandal, D. K., M.Sc., Zoological Assistant, Insect Section, Zoological Survey of India, 34 Chittaranjan Avenue, Calcutta-12

Mandahar, C. L., M.Sc. (Hons.), Ph.D., Lecturer in Botany, Kurukshetra University, Kurukshetra (Panjab).

Mansingh, Abhai, M.Sc., D.Phil., Senior Research Fellow, Physics Department, University of Allahabad, Allahabad.

*†Mani, M. S., D.Sc., Deputy Director, Zoological Survey of India, 34 Chitaranjan Avenue, Calcutta-12.

Mann, R. S., M.Sc., M.Ch.E. Ph.D., ·F.R.I.C., Associate Professor Department of Chemical Engineering, University of Ottawa, Ottawa (Canada).

Mathur, B. L., M.Sc., Ph.D., Asst. Plant Pathologist, Plant Pathology Section, A-30 Tilak Nagar, Jaipur.

Mathur, B. P., M.Sc., c/o Dr. Tara Shanker Mathur, Brij Kutir, Arvind Marg, Jaipur.

*†Mathur, K. N., D.Sc., F. Inst.P., Director, Central Scientific Instrument Organisation, C. S. I. R. Building, Rafi Marg, New Delhi-1.

†Mathur, P. B., M.Sc., D.Phil., Senior Scientific Officer, Central Electro-chemical Research Institute, Karaikudi-3 (S. India).

*†Mattoo, B. N., M.Sc., Ph.D., D.Sc., Senior Physicist, Forensic Science Laboratory, Government of Maharastra, Bombay-1.

*†Mehra, H. R., M.Sc., Ph.D., F. N. I., 33 Chatham Lines, Allahabad-2.

*Mehra, P. N., D.Sc., F.N.I., F.B.S., Professor and Head of the Department of Botany, Panjab University, Chandigarh-3.

†Mehra, Ram Krishna, M.Sc., Assistant Professor of Zoology, University of Allahabad, Allahabad.

*†Mehrotra, A. P., M.Sc., D.Phil., F.B.S., P.E.S.(1), Professor and Head of the Department of Botany, D. S. B. Government Degree College, Naini Tal.

*Mehrotra, B. S., M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad.

Mehrotra, P. N., M.Sc., 60 Circular Road, Ranchi (Bihar).

*†Mehrotra, R. C., M.Sc., D.Phil., Ph.D., F.R.I.C., F.N.I., Professor and Head of the Department of the Chemistry, University of Rajasthan, Jaipur.

Mehrotra, R. S., M.Sc. Ph.D., Asstt. Professor of Botany, University of Saugar, Sagar.

*†Mishra, R. S., M.Sc., Ph.D., D.Sc., F.N.I., Professor and Head of the Department of Mathematics, University of Allahabad, Allahabad.

*Misra, M. L., D.Sc., Professor and Head of the Department of Mathematics, University of Saugar, Sagar.

*Misra, R., M.Sc., Ph.D., F.B.S., F.N.I., Professor and Head of the Department of Botany, Banaras Hindu University, Varanasi-5.

*†Misra, R. C., M.Sc., Ph.D., F.G.M.S., M.M.G.I., F.P.S., Professor and Head of the Department of Geology, University of Lucknow, Lucknow.

*†Misra, R. D., M.A., Ph.D., Member, Public Service Commission, U. P., 2-A Pannalal Road, Allahabad-2.

†Misra, S. G., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

*†Mitra, A. K., M.Sc., Ph.D., Reader in Botany, University of Allahabad, Allahabad.

†Mukerji, G. P., M.Sc., Head of the Department of Zoology, J. H. Government College, Betul (M. P.).

*†Mukherji, M. K., M.Sc., Ph.D., "Arun Prabha", Kalianiwas, P. O. Barrackpore, 24 Paraganas (W. B.).

†Mukherji, P. K., M.Sc., Ph.D., F.B.S., No. 3, Tuka Ram Chawl, Sadar Bazar, Nagpur.

Mukherjee, S. R., M.Sc., D.Phil., Lecturer in Engineering Mathematics, Engineering College, Banaras Hindu University, Varanasi-5.

Murthy, S. N., M.Sc., Lecturer in Mathematics, G. S. Technological Institute, Indore.

*†Mushran, S. P., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

Nagar, S. K., M.Sc., 18 Telegraph Traffic Place, Baird Road, New Delhi.

Naik, Y. G., M.Sc., Ph.D., Principal Professor of Physics and Dean of the Faculty of Science, Gujarat College, Ahmedabad.

Nair, G. U., M.Sc., Research Assistant, Botany Department, Christ Church College, Kanpur.

Narain, Udai, M.Sc., Head of the Botany Department, Rajendra College, Chapra.

*Narlikar, V. V., M.A., F.R.A.S., F.N.I., F.A.Sc., Chairman, Rajasthan Public Service Commission, 7 Jaipur Road, Ajmer.

*†Nath, Raj, Ph.D., D.I.C., F.N.I., Professor and Head of the Department of Geology, Banaras Hindu University, Varanasi-5.

*†Nigam, S. S., M.Sc., Ph.D., D.I.C., Reader in Chemistry, University of Saugar, Sagar.

Oak, Mr. Justice V. G., B.Sc. (Hons.), I.C.S., 1A-Beli Road, Allahabad-2.

Ojha, S. N., M.Sc., Assistant Rice Specialist, Agricultural Research Institute, Pusa (Dt. Darbhanga) Bihar.

Ojha, S. N., M.Sc., Asst. Professor of Agriculture, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

*†Pal, N. L., D.Sc., Plant Physiologist, Central Tobacco Research Institute Rajahmundry.

*†Pandey, B. P., D.Sc., Professor of Parasitology, U. P. College of Veterinary Science and Animal Husbandry, Mathura.

Pandey, Ravi, M.Sc., Head of the Department of Zoology, C. M. D. Degree College, Bilaspur (M. P.).

Pandeya, S. C., M.Sc., Ph.D., Reader in Botany, University School of Sciences, Ahmedabad-5.

Pandit, C. S., M.Sc., Lecturer in Chemistry, Holkar Science College, Indore (M. P.).

Panigrahi, Gopinath, B.Sc. (Hons.), M.Sc., Ph.D., Regional Botanist, Central Circle, Botanical Survey of India, 10 Chatham Lines, Allahabad-2.

*Pannikar, N. K., M.A., D.Sc., F.A.S., F.N.I., F.Z.S.I., Director, Indian Programme, Indian Ocean Expedition, Council of Scientific and Industrial Research, Rafi Marg, New Delhi-1.

*†Parija, P., M.A., D.Sc., F.N.I., F.A.Sc., I.E.S. (Retd.), Vice-Chancellor, Utkal University, Vani Vihar, Bhubaneswar (Orissa).

Patel, Vishnu Shankar, M.Sc, Asstt. Professor of Chemistry, M. V. Mahavidyalaya, Bhopal.

Pathak, Hari Datt, M.Sc., Assistant Professor of Chemistry, D. S. B. Government College, Naini Tal.

Pathak, R. S., M.Sc., Research Scholar in Mathematics, Banaras Hindu University, Varanasi-5.

*Patil, Ramakant Pandurang, B.A., M.Sc. Ph.D., Botanist, Central Botanical Laboratory, 76 Acharya Jagadish Bose Road, Calcutta-14.

*†Paul, Ram Chand, M.Sc., Ph.D., F. R. I. C., Professor and Head of the Chemistry Department, Panjab University, Chandigarh-3.

*†Perti, O. N., M.Sc., D.Phil, Professor and Head of the Department of Chemistry, D. S. B. Government Degree College, Naini Tal.

Potay, S. K., M.Sc., Senior Scientific Assistant, Defence Metallurgical Research Laboratory, Phisalbanda, P. O. Yakutpura, Hyderabad (A. P.).

Prakash, Nam, M.Sc., c/o Shri Agun Prasad, Kaillawallen Street, Delhi Gate, Ghaziabad.

*†Prakash, Ved, M.Sc., Principal, R. S. D. College, Ferozepore City.

Prasad, A. R., M.Sc., Asstt. Professor of Entomology, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

*Prasad, Balbhadra, D. Sc., F. N. I., Department of Chemistry, Patna University, Patna-5.

*†Prasad, B. N., M.Sc., Ph.D., D.Sc., F.N.I., Laxmi Niwas, Lowther Road, George Town, Allahabad-2.

†Prasad, B. N., M.Sc., Ph.D., F. L.S., F.B.S. Department of Botany, University of Lucknow, Lucknow.

Prasad, Devendra, M.Sc., Ph.D., F.A.Z., Reader and Head of the Zoology Department, Science College, Patna-5.

Prasad, Mahendra, ·M.Sc., Dr.rer-Nat., Reader in Botany, Ranchi College, Ranchi.

*†Prasad, Mata, D.Sc., F.R.I.C., F.N.I., Mathura Niwas, 4281 Pipal Mandi, Agra.

Prasad, P., B.Sc. (Hons.), M.A., Asstt. Professor of Mathematics, L. S. College, Muzaffarpur.

Prasad, R. K., B.Sc. (Hons.), M.Sc., Ph.D., Lecturer in Chemistry, L. S. College, Muzaffarpur.

*Prasad, Sarju, M.A., M.Sc., D.Sc., Reader in Chemistry, Banaras Hindu University, Varanasi-5.

Prasad, S. S., M.Sc., Head of the Botany Department, L. S. College, Muzaffarpur (Bihar).

*Puri, V., M.Sc., D.Sc., F.B.S., F.A.Sc., F.N.I., Professor and Head of the Botany Department, Meerut College, Meerut.

†Purohit, D. N., M.Sc., Ph.D., c/o Pt. L. N. Purohit, Advocate, Naya Shahar, Idgah Bari, Bikaner.

Purushottam G., M.A., Department of Mathematics, Science College, Osmania University, Hyderabad-Dn. 7 (A. P.).

Raghuvanshi, S. S. M.Sc., D.Phil, Assistant Professor of Botany, Lucknow University, Lucknow.

Rajagopal, T., M.Sc., Research Scholar, Botanical Survey of India, Central Circle, 10 Chatham Lines, Allahabad.

Rajvanshi, S. C., M.Sc., Lecturer in Mathematics, Faculty of Engineering, University of Jodhpur, Jodhpur.

*†Rai, M. M., M.Sc., D.Phil., Professor of Chemistry, Government Agricultural College, Jabalpur.

Rai, P., B.V.Sc.&A.H., M.V.Sc., Assistant Professor of Parasitology, U. P. College of Veterinary Science and Animal Husbandry, Mathura.

†Rai, Rama Shanker, M.Sc., D.Phil., Department of Chemistry, University of Rajasthan, Jaipur.

Rai, U. K., M.Sc., D.Phil., Oil Seeds Specialist, Agricultural Research Institute, Sabour (Bhagalpur).

Ramakrishan, P. S., M.Sc., Ph.D., Department of Botany, Panjab University Chandigarh.

[143]

*†Ramamoorthy, B., M.Sc., D.Phil., Assoc.I.A.R.I., Physical Chemist, Division of Chemistry, Indian Agricultural Research Institute, New Delhi-12.

Raman, S. S., M.Sc., Ph.D., Lecturer in Botany, Banaras Hindu University, Varanasi-5.

Ramaswamy, K. R., B.Sc. (Hons.), M.Sc., Ph.D., Lecturer in Zoology, Karnatak University, Dharwar (Mysore).

*†Ramdas, L. A. M.A., Ph D., F.N I., F.A.Sc., F.R.Met.Soc., National Physical Laboratory, New Delhi-12.

*†Ramiah, K., M.Sc. D.Sc. (Hony.), F.N.I., F.A.Sc., Swathi, 552 XIX Cross Road, Bangalore-12.

*Ranade, J. D., M.Sc., Ph.D., A.Inst.P., Assistant Professor of Physics, University of Saugar, Sagar..

*†Randhawa, M. S., M.Sc., D.Sc., F.N.I., I.C.S., Adviser (Resources), Planning Commission, New Delhi-1.

*†Ranjan, S., M.Sc., D.Sc., F.N.I., F.A.Sc., Vice-Chancellor, Agra University, Agra.

Rao, A. L. Jagannadha, M.Sc., Lecturer in Chemistry, Punjabi University, Patiala (Panjab).

Rao, D. Rama Krishna, M.A., Lecturer in Mathematics, Department of Technical Education, Nehru Nagar, Secunderabad (A. P.)

Rao, Digambar, M.Sc., Research Scholar in Botany, College of Science, Osmania University, Hyderabad-7.

Rao, D. Rameshwar, M.A., Research Scholar, 11-1-243, Sitafalmandi, Secunderabad.

Rao, G. Teeka, M.A., Lecturer in Mathematics, Department of Chemical Technology, Osmania University, Hyderabad.

Rao, K. M., M.A., Department of Mathematics, J. T. S. Govt. Polytechnic, Vijayawada (A.P.).

Rao, K. S., M.Sc., Lecturer in Zoology, Government Science College, Rewa.

Rao, M. Rama Mohana, M.A., Lecturer in Mathematics, College of Engineering, Osmania University, Hyderabad-7.

†Rao, S. N., M.Sc., Ph.D., F.R.E.S., F.A.Z., Head of the Zoology Department, Madhav College, Ujjain.

Rao, V. V. L. N., M.A., Reader in Mathematics, Osmania University, 1-5-106 Mushirabad, Hyderabad-Dn-20.

Rathie, P. N., M.Sc., Lecturer in Mathematics, Faculty of Engineering, University of Jodhpur, Jodhpur.

*Rawat, J. S., M.Sc., Ph.D., Assistant Professor, Department of Physiology and Biochemistry, U. P. College of Veterinary Science and Animal Husbandry, Mathura.

*Raychaudhuri, S. P., M.Sc., Ph.D., D.Sc., F.R.I.C., F.N.I., Senior Specialist (Land Resources), Planning Commission, Yojana Bhavan, Parliament Street, New Delhi-1.

Rasul, S. H., B.Sc.(Hons.), M.Sc., Ph.D.Tech., F.P.S., F.G.S., Reader, Head of the Geology Department, Aligarh Muslim University, Aligarh.

*†Roy, Arabinda, M.Sc., Ph.D., Professor of Physiology and Biochemistry, U. P. College of Veterinary Science, Mathura.

*†Sadhu, D. P., M.Sc., Ph.D., Principal, Post-Graduate College of Animal Sciences, I.V.R.I., Izatnagar (U. P.).

Sahai, Rajendra, M.Sc., Asstt. Professor of Botany, University of Gorakhpur, Gorakhpur.

*†Sahni, (Mrs.) Savitri, M.Sc., Director, Birbal Sahni Institute of Palaeobotany, University Road, Lucknow.

†Saksena, B. B. L., M.A., M.Sc., L.T., Assistant Professor of Botany, K. N. Govt. Degree College, Gyanpur (Varanasi).

†Saksena, J. N., M.Sc., Ph.D., Professor in Zoology, Government Science College, Rewa (M. P.).

†Saksena, R. D., M.Sc., Ph.D., F.Z.S.I., Professor of Zoology, Balwant Rajput College, Agra.

*†Saksena, R. K., D.Sc., F.N.I., 385/6 Circular Road, P. O. Botanical Gardens, Howrah.

*†Saksena, S. B., M.Sc., Ph.D., F.B.S., Reader in Botany, University of Saugar, Sagar.

Sant, H. R., M.Sc., Ph.D., Lecturer, Botany Department, Banaras Hindu University, Varanasi-5.

Sarkar, D. C., Ph.D., Reader and Acting Head of the Physics Department, Muslim University, Aligarh.

Sarma, K. P., M.A., Research Scholar, Department of Mathematics, Osmania University, Hyderabad (A. P.).

*Satyanarayana, Y., B.Sc., Ph.D., Ecologist, Central Arid Zone Research Institute, Jodhpur.

*†Saxena, B.B.L., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

†Saxena, D. B., M.Sc., D.Phil., F.A.Z., M.Z.S., F.I.H.S., Mubarak Manzil, Opp. Sher Garai Police Station, Haft Chinnar, Srinagar (Kashmir).

Saxena, R. K., M.Sc., Lecturer in Mathematics, Govindram Seksaria Technological Institute, Opp. Nehru Park, Indore.

Saxena, Ram Kishore, M.Sc., Ph.D., 276 Shiv Road, Ratanada, Jodhpur.

Saxena, S. C., M.Sc., Ph.D., D.I.C., F.R.E.S., Reader in Zoology, University of Rajasthan, Jaipur.

*†Sen, Bisheswar, B.Sc., Director, Vivekananda Laboratory, Almora.

Sen, D. N., D.Sc., Department of Botany, University of Jodhpur, Jodhpur.

Shafi, S. Md., M.Sc., Lecturer in Zoology, Ranchi College, Ranchi.

Shanker, Hari, M.Sc. D.Phil., Assistant Professor of Agricultural Chemistry, Govt. Agricultural College, Kanpur.

Sharma, A. P., M.Sc., Lecturer in Physics, Aligarh Muslim University, Aligarh.

Sharma, B. B., B.Sc.(Hons.), M.Sc., Ph.D., F.B.S., Department of Botany, University of Lucknow, Lucknow.

*†Sharma, D., M.Sc., D.Phil., Professor and Head of the Department of Physics, University of Gorakhpur, Gorakhpur.

†Sharma, G. P., M.Sc., Ph.D., F.N.I., F.A.Z., F.I.A.Z., F.Z.S., F.Z.S.I., F.R.M.S., Professor and Head of the Zoology Department, Panjab University, Chandigarh-3.

Sharma, K. C., Ph.D., Lecturer in Mathematics, University of Rajasthan, Jaipur.

†Sharma, M. N., M.Sc., Ph.D., F.I.P.S., Grad. I.T.E. Lecturer in Physics, Lucknow University, Lucknow.

Sharma, P. C., M.Sc., Research Scholar in Botany Department, University of Lucknow, Lucknow.

Sharma, S. K., M.Sc., Junior Scientific Officer, Room No. 31, National Physical Laboratory, New Delhi-12.

Shetty, H. P. C., M.A., M.Sc., Research Officer, Central Inland Fisheries Research Institute, Barrackpore, W. B.

Shivahare, G. C., M.Sc., Ph.D., Reader in Chemistry University of Jodhpur, Jodhpur.

Shiveshwarkar, S. W., B.Sc., M.A., I.C.S., Additional Member, Railway Board, Rail Bhawan, New Delhi.

Shrivastava, M. M. P., Ph.D., Professor of Agriculture, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

Shrivastava, R. K., M.Sc.. D.Sc., Asstt. Professor of Zoology, Nagpur University, L. I. T. Buildings, Nagpur.

Shukla, Bhola Nath, M.Sc., Lecturer in Science, Govt. Higher Secondary School, Janjgir (Distt. Bilaspur), M. P.

Shukla, G. S., M.Sc. Ph.D., Assistant Professor of Zoology, University, of Gorakhpur, Gorakhpur.

Siddiqui, Md. Mahfooz Ali, M.A., B.Sc., Ph.D., Lecturer in Mathematics, Osmania University, Hyderabad-7 (A. P.).

*Sidhu, G. S., B.Sc. (Hons.), MSc., Ph.D., Director, Regional Research Laboratory, Hyderabad-9.

*†Singh, Amar, M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad,

†Singh, Babu, M.Sc., Ph.D., D.I.C., Professor of Botany, Government Agricultural College, Kanpur.

*Singh, Balwant, D.Sc., F.R.I.C., P.E.S.I. (Retd.), Head of the Chemistry Department, Punjabi University, Patiala.

*Singh, B. N., M.Sc., Ph.D., D.Sc., Director (Microbiology), Central Drug Research Institute, Lucknow.

Singh, C. M., M.Sc., Ph.D., Dean, College of Veterinary Science, Punjab Agricultural University, Hissar (Punjab).

Singh, C. P., M.Sc., Lecturer in Zoology, L. S. College, Muzaffarpur.

Singh, D. D. N., MSc., Ph.D,, Lecturer in Botany, Science College, Patna-5

Singh, D. V., M.Sc., Field Officer, Pests and Diseases, I. A. D. P., Ramghat Road, Aligarh.

†Singh, Eric John, M.Sc., D.Phil, North West Institute for Medical Research, 5651 West Addison Street, Chicago-34, Illinois (U.S.A.).

Singh, J. S., M.Sc., Research Scholar, Department of Botany, Banaras Hindu University, Varanasi-5.

Singh, Karan, M.Sc., Lecturer in Botany, University of Jodhpur, Jodhpur.

Singh, K. K., M.Sc., Lecturer in Chemistry, R. D. S. College, Muzaffarpur.

Singh, K. P., M.Sc., Asst. Prof. of Horticulture, Tirhut College of Agriculture Dholi (Dt. Muzaffarpur), Bihar.

Singh, M. P., M.Sc., Lecturer in Zoology, L. S. College, Muzaffarpur.

Singh, Pratap, M.A., Research Scholar in Mathematics, Birla College, Pilani.

†Singh, P. N., M.Sc., D.Phil., Asst. Agricultural Chemist, Agricultural Chemistry Laboratory, Durgapur, Jaipur (Rajasthan).

Singh, Rameshwar, M.Sc., Ph.D., Maize and Millet Specialist, Agricultural Research Institute, Dholi (Dt. Muzaffarpur), Bihar.

Singh, R. B., B.A. (Hons.), M.A., Lecturer in Mathematics, L. S. College, Muzaffarpur.

Singh, R. M., B.Sc. (Hons.), M.Sc., Lecturer in Mathematics, L. S. College Muzaffarpur.

*Singh, R. N., M.Sc., D.Phil., Principal, Govt. Arts and Science College, Durg (M. P.).

Singh, R. N., M.Sc., C-4/294 Govardhan Sarai, Chetganj, Varanasi.

Singh, R. P., M.Sc., Lecturer in Mathematics (Statistics), M. V. Mahavidyalaya, Bhopal.

Singh, Sant, M.Sc., Ph.D., Reader in Agricultural Chemistry and Head of the Agricultural Chemistry Section, College of Agriculture, Banaras Hindu University, Varanasi-5.

Singh, S. B., M Sc., Ph.D., F.Z.S., F.R.E.S., Reader in Zoology, L. S. College, Muzaffarpur.

Singh, S. P., M.Sc., c/o Dr. B. D. Pande, 1102 West Oregaon Street, Urbana, Illinois (U. S. A.).

Singh, Uma Shankar, M.Sc. Tech., Dr. Ing., Sectional Engineer, Balpahar Refractories Ltd., P. O. Karuppur (Distt. Salem), Madras State.

†Singh, U. S., M.Sc., Vigyan Ratna, D.Phil., Cotton Physiologist, Govt. Cotton Research Station, Raya (Mathura).

Singh, Y. P., M.Sc., Research Scholar in Mathematics, B. I. T.S., Pilani.

Sinha, B. M., M.Sc., Ph.D., Reader in Zoology, School of Studies in Zoology, Vikram University, Ujjain.

Sinha, K. D. P., M.Sc., Ph.D., Professor of Mathematics, Bihar University, L. S. College, Muzaffarpur.

Sinha, M. K., M.Sc., Asst. Professor of Agricultural Chemistry, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

Sinha, N. P., M.Sc., Ph.D., Professor of Agricultural Chemistry, Tirhut College of Agriculture, Dholi (Muzaffarpur), Bihar.

Sinha, N. S., B.Sc., (Agri.), Assoc.I.A.R.I., Physiological Chemist, Crop Physiology Section, T. G. Civil Lines, Lucknow.

Sinha, R. R., M.Sc., Lecturer in Botany, L. S. College, Muzaffarpur.

Sinha, S., M.Sc., Ph.D., Head of the Department of Botany, Agra College, Agra.

†Sreeramulu, T., M.Sc., Ph.D., D.I.C., Reader in Botany, Andhra University, Waltair (A.P.).

Srivastava, A. S., M.Sc., D.Phil., Ph.D., Entomologist to Government and Officer-in-Charge, Plant Protection Service, U. P., Kanpur.

Srivastava, B. K., M.Sc., D.Phil., Asst. Professor of Zoology, University of Saugar, Sagar.

*†Srivastava, B. N., D.Sc., F.N.I., Professor of General Physics, Indian Association for the Cultivation of Science, Jadavpur, Calcutta-32.

Srivastava, B. N., M.Sc., Lecturer in Chemistry, D. A. V. College, Dehra Dun.

Srivastava, C. M., M.Sc., Lecturer in Zoology, Ranchi College, Ranchi.

*†Srivastava, D. S., M.Sc., Ph.D., F.R.M.S., F.R.E.S., Professor and Head of the Department of Zoology, University of Saugar, Sagar.

*Srivastava, G. D., M.Sc., B Beli Road, Allahabad-2.

*Srivastava, H. D., M.Sc., D.Sc., F.N.I., Director, Indian Veterinary Research Institute, Izatnagar.

Srivastava, H. M., M.Sc., Laxmi Timber Mart, Chaupasani Road, Jodhpur.

Srivastava, H. P., M.Sc., Research Scholar, Department of Botany, University of Allahabad, Allahabad.

†Srivastava, K. N., M.Sc. D.Phil., Lecturer in Mathematics, M. A. College of Technology, Bhopal (M.P.).

*†Srivastava, M. D. L., D.Sc., Professor and Head of the Department of Zoology, University of Allahabad, Allahabad.

†Srivastava, O. N., M. Sc., D.Phil., Head of the Department of Zoology, K. N. Govt. College, Gyanpur (Varanasi).

*†Srivastava, P. L., M.A., D.Phil., F.N.I., Vice-Chancellor, Bihar University, Muzaffarpur.

†Srivastava, (Miss) Pramila, M.A., D.Phil., D.Sc., Reader in Mathematics, Banaras Hindu University, Varanasi-5.

Srivastava, P. S., M.Sc., Department of Zoology, S. B. R. College, Bilaspur (M.P.).

Srivastava, R. B., M.Sc., Lecturer in Botany,'L. S. College, Muzaffarpur.

Srivastava, Rajendra Prasad, M.Sc., Ph.D., Assistant Professor of Zoology, University of Lucknow, Lucknow.

†Srivastava, R. K., M.V.Sc., Ph.D., Asst. Professor of Biochemistry, College of Veterinary Science and Animal Husbandry, Mathura.

Srivastava, R. K., M.Sc., D.Phil., Senior Research Fellow, C. S. I. R., Botany Department, University of Allahabad, Allahabad.

Srivastava, R. P., M.Sc., Head of the Physics Dept., S. B. R. College, Bilaspur (M.P.).

Srivastava, R. P., M.Sc., Ph.D., Lecturer in Zoology, School of Basic Sciences, University of Udaipur, Udaipur.

†Srivastava, S. K., B.Sc. (Hons.), M.Sc., Kokaghat, Uprahti, Rewa.

Srivastava, S. L., M.Sc., Lecturer in Botany, K. N. Government College, Gyanpur.

Srivastava, S., B.Sc. (Hons.), M.Sc., Asst. Professor of Agricultural Botany, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur), Bihar.

Srivastava, S. N., M.Sc., Professor of Agricultural Engineering, Tirhut College of Agriculture, P. O. Dholi (Dt. Muzaffarpur) Bihar.

†Srivastava, S. N., M.Sc., D.Phil., Department of Zoology, L. S. College, Muzaffarpur.

Srivastava, S. P., M.Sc., D.Phil., Reader in Chemistry, Regional Institute of Technology, Jamshedpur.

*†Srivastava, U. S., M.Sc., M.Ed., D.Phil., Professor of Zoology, University of Bihar, Muzaffarpur.

Sundararajan, P. K., B.A. (Hons.), Lecturer in Mathematics, St. Francis de Sales' College, Seminary Hills, Nagpur.

Sukhani, T. R., M.Sc., Lecturer in Zoology-Entomology, Government Agricultural College, Kanpur.

*Sur, N. K., D.Sc., F.N.I., 74 Tagore Town, Allahabad-2.

*†Swarup, H., M.Sc., Ph.D., F.S.Z., Professor and Head, School of Studies in Zoology, Vikram University, Ujjain.

Swarup, K., M.Sc., D.Phil., Department of Zoology, University of Gorakhpur, Gorakhpur.

*Tandon, Amar Nath, M.Sc., D.Phil., Seismologist, Meteorological Office, Lodi Road, New Delhi-3.

Tandon, M. P., M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad.

*†Tandon, R. N., M.Sc., Ph.D., D.I.C., F.A.Sc., F.N.I., Professor and Head of the Department of Botany, University of Allahabad, Allahabad.

*†Tandon, R. S., M.Sc, D.Phil., F.A.Z., F.H.S., Assistant Professor of Zoology, University of Lucknow, Lucknow.

*†Tandon, S. P., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

*†Tewari, H. B., M.Sc., D.Phil., Ph.D., F.Z.S., F.R.M.S., Head of the Zoology Dept., University of Udaipur, Udaipur.

†Tewari, Col. S. G., M.Sc., 4 Balrampur House, Allahabad-2.

Thakur, C., M.S., Ph.D., Principal and Regional Director, Agricultural Research Institute, Dholi (Dt. Muzaffarpur) Bihar.

*Thind, K. S., M.Sc., Ph.D., Reader in Botany, Panjab University, Chandigarh-3.

Tiagi, Yagya Datta, M.Sc., Ph.D., Assistant Professor of Botany, University of Saugar, Sagar.

†Tiwari, I. P., M.Sc., Assistant Professor of Zoology, K. Government Arts and Science College, Raigarh.

*†Tiwari, R. D., M.Sc., D.Phil., Asstt. Professor of Chemistry, University of Allahabad, Allahabad.

Tripathi, L. M., M.A., Research Scholar in Mathematics, University of Allahabad, Allahabad.

Tripathi, O. N., M.Sc., LL.B., Ph.D., Head of the Department of Chemistry, Govt. Degree College, Ambikapur, Distt. Sarguja (M. P.)

Tripathi, Y. R. D.Sc., Deputy Director, Fisheries, Department of Animal Husbandry and Fisheries, Badshah Bagh, Lucknow.

Tripathy, A. N., M.Sc., Lecturer in Mathematices, L. S. College, Muzaffarpur.

Upadhya, V. N., M.Sc., F.P.S., Professor of Physics, S. B. Garda College, Navsari.

Varkey, T. J., M.Sc., Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto (Canada).

*†Varma, D. N., M.Sc., D.Phil., F.A.Z., New Darbhanga Colony, 29 C. Y. Chintamani Road, Allahabad-2.

*Venkataraman, G. S., M.Sc., Ph.D., F.N.G.S., Microbiologist (Algae), Division of Microbiology, Indian Agricultural Research Institute, New Delhi-12.

Verma, C. B. L., M.A., Professor of Mathematics, Science College, Raipur (M. P.).

Verma, D. M., M.Sc., Technical Assistant, Central Circle, Botanical Survey of India, 10 Chatham Lines, Allahabad-2.

*Verma, G. S., M.Sc., Ph.D., F.L.S., F.R. Hort.S., F.B.S., Reader in Botany, University of Lucknow, Lucknow.

Verma, R. C., M.Sc., Reader in Mathematics, Government Engineering College, Jabalpur.

Verma, S. C., M.Sc. (Hons)., Lecturer in Botany, Panjab University, Chandi-garh.

Verma, S. K. C., M.Sc., Asst. Professor of Agriculture, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

Verma, V. K., B.Sc. (Hons.), M.Sc., Lecturer in Geology, Faculty of Engineer-ing, University of Jodhpur, Jodhpur.

Verma, V. K , M.Sc., Ph.D., Department of Mathematics, M. A. College of Technology, Bhopal.

†Vyas, K. D., B.Sc., M.B.B.S., Assistant Professor of Bacteriology, Department of Home Science, University of Allahabad, Allahabad.

Vyas, L. N., M.Sc., Ph.D., Head, Department of Botany, M. B. College, Udaipur (Rajasthan).

Wadhwa, B. M., M.Sc.(Hons), Systematic Botanist, Botanical Survey of India, Central Circle, 10 Chatham Lines, Allahabad-2.

*†Wadia, D. N., M.A., D.Sc., F.G.S., F.A.S., F.N.I., F.R.S., Geological Adviser to Govt. of India, Department of Atomic Energy, South Block, Central Secretariat, New Delhi.

*†West, W. D., M. A., Sc.D., F.A.S., F.N.I., Professor and Head of the Depart-ment of Appiled Geology, University of Saugar, Sagar.

-†Weyl, Nathaniel, B.Sc., F.I.A.L., Writer, 4201 S Ocean Blyd., Delroy Beach, Fla. (U.S.A.).

Wilson, K. I., M.Sc., 101 P. G. Hostel, Old Wing, I.A.R.I., New Delhi-12.

†Yadav, J. S. P., M.Sc.Ag., Ph.D., A.I.A.R.I. Dip.For., F.C.S., Soil Chemist, Forest Research Institute and Colleges, P.O. New Forest, Dehra Dun.

Yadav, R. S., M.Sc., Lecturer in Physics, Muslim University, Aligarh.

*†Zaheer, S. H., M.A., Dr. Phil.Nat., Director General, Council of ✶Scientific and Industrial Research, Rafi Marg, New Delhi-1.